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#148 SEPTEMBER 2017

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out in the wilderness

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The return of

DARK SKIES

17 PAGES OF THE MONTH'S
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BUZZ ALDRIN

"We've been stuck
in low-Earth orbit
for too long"

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We speak to the NASA
scientist planning
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This month's contributors include...

Maggie Aderin-Pocock

Sky at Night presenter

Maggie joins the hunt for space rocks in an unlikely location – the roof of the Norman Lockyer Observatory. *Page 21*

Ben Evans

Space exploration expert

Ben recounts the highs of the Cassini mission at Saturn, which comes to an end this month with a death-dive into its atmosphere. *Page 32*

Daniel Lynch

Eclipse chaser

Daniel explains how to take your eclipse photos to the next level with a tutorial on coaxing detail from the Sun's corona. *Page 84*

Jenny Winder

Science writer

Jenny charts the Voyager mission's incredible quest to the outer Solar System and into the unknown of interstellar space. *Page 67*

Welcome

Longer nights mean more opportunities for an astro adventure

Now that the evenings are once again starting earlier and we can look forward to longer nights, it could be time to consider observing from somewhere more remote – to do some wild astronomy. Whether you are excited by an expedition up to high moorland or want to make an evening trip just out of town, on page 38 Will Gater is your guide to how to pull this off successfully and safely. Dark skies await!

Saturn is sure to be one of the targets to view in darker skies this month, and on the 15th the Cassini mission at the Ringed Planet comes to a dramatic end with a final plunge into the planet's interior. Ben Evans looks back at 13 years of science at Saturn and explains why destruction is the best ending for the spacecraft on page 32.

Not all spacecraft have such abrupt endings. The twin Voyager probes are still going, and this month we celebrate the mission's 40th anniversary. On page 67, Jenny Winder charts a journey that has rewritten our understanding of the Solar System and propelled the Voyagers into the record books.

Enjoy the issue!

Chris Bramley Editor

PS Our next issue goes on sale 21 September.

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Sky at Night Lots of ways to enjoy the night sky...

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Find out what *The Sky at Night* team will be exploring in this month's episode on page 19

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Highlights

The Sky at Night

While astronomy and planetary exploration have revealed many of the secrets of the Solar System, until recently not much was known about what lies beyond Neptune. In July's *The Sky at Night*, the team find out more about this mysterious outer realm, while Pete Lawrence attempts to observe a trans-Neptunian object using amateur equipment.

Interview: returning to the ice giants

NASA's Mark Hofstadter on why we need to return to Uranus and Neptune, and how we can do it.

Sneak preview: Planet Factory

Download the first chapter of Elizabeth Tasker's book on the hunt for planets outside the Solar System.

Vacation Guide to the Solar System

Print out these retro-style postcards imagining a future in which planetary tourism is the norm.

and much more...

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EVERY MONTH
Virtual Planetarium

With Paul Abel and Pete Lawrence

Explore September's night-sky highlights with Paul and Pete.

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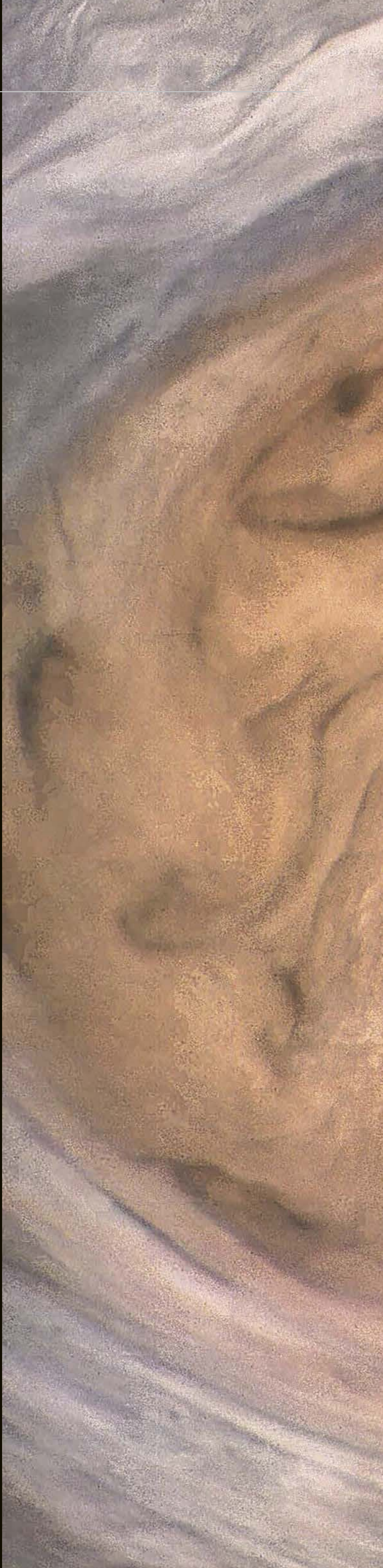
Juno on the spot

Jupiter's Great Red Spot appears as we've never seen it before, courtesy of the Juno spacecraft's recent close pass over this swirling, centuries-old storm

JUNO SPACECRAFT, 11 JULY 2017



NASA/JPL-CALTECH/SWRI/MSSS/KEVIN GILL

September marks 40 years since the launch of the Voyager spacecraft, which visited the four outer giant planets of the Solar System and 48 of their moons. It was humanity's reconnaissance mission, enticing us with incredible planetary encounters and inspiring the current era of planetary exploration: Cassini, New Horizons and most recently the Juno mission to Jupiter.

In July this year Juno celebrated its own anniversary – one year since its arrival in Jupiter's orbit – with a close flyby over the Great Red Spot, gifting us with an unprecedented view of the huge storm. On 11 July at 01:55 UT it flew within 9,000km over the ruddy anticyclone, capturing images of it with the JunoCam instrument.

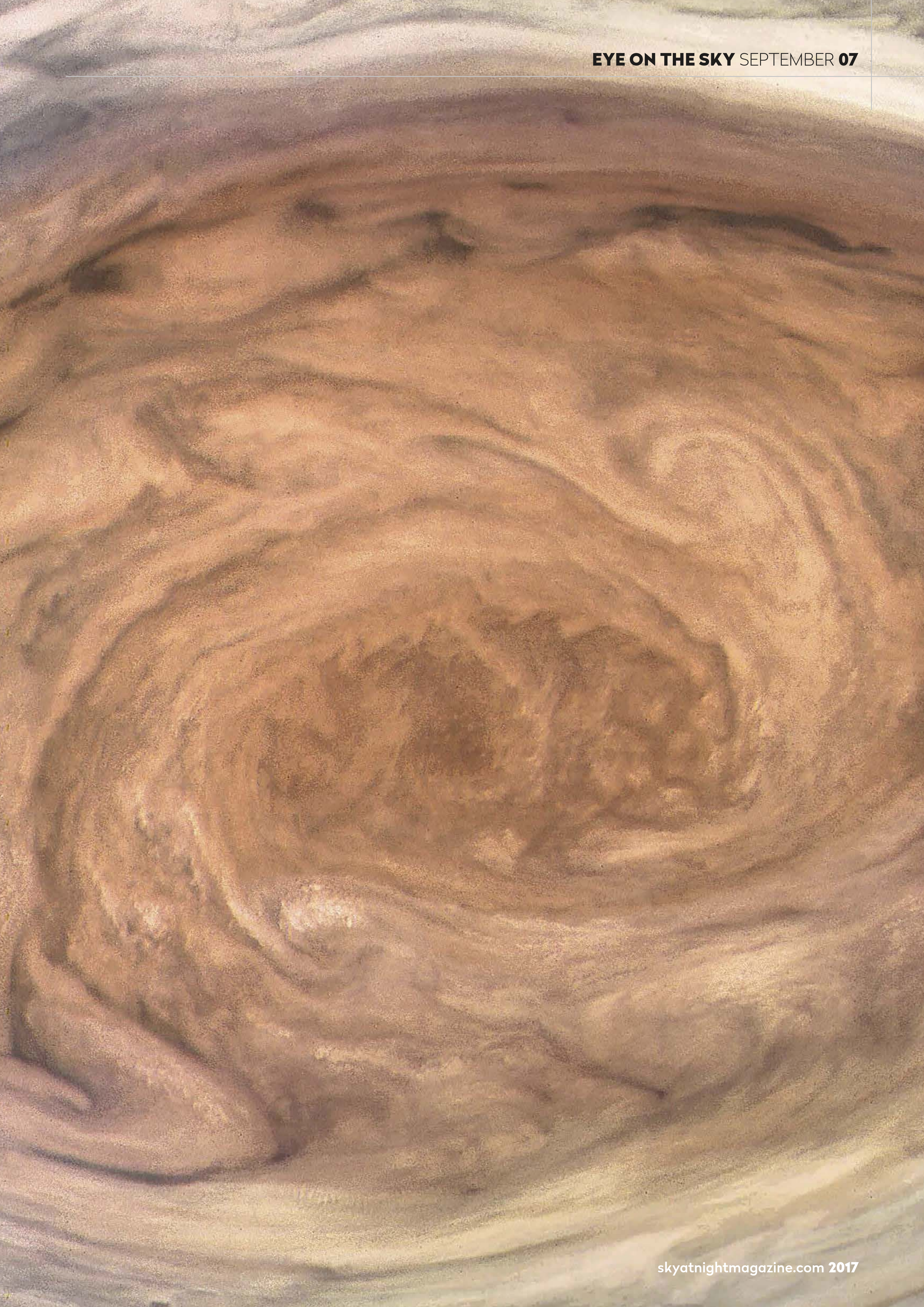
The Great Red Spot appears to be shrinking, but it's an astounding 16,350km wide, which still makes it about 1.3 times as wide as Earth. It has been monitored by humanity since about 1830, and may have been raging for over 350 years.

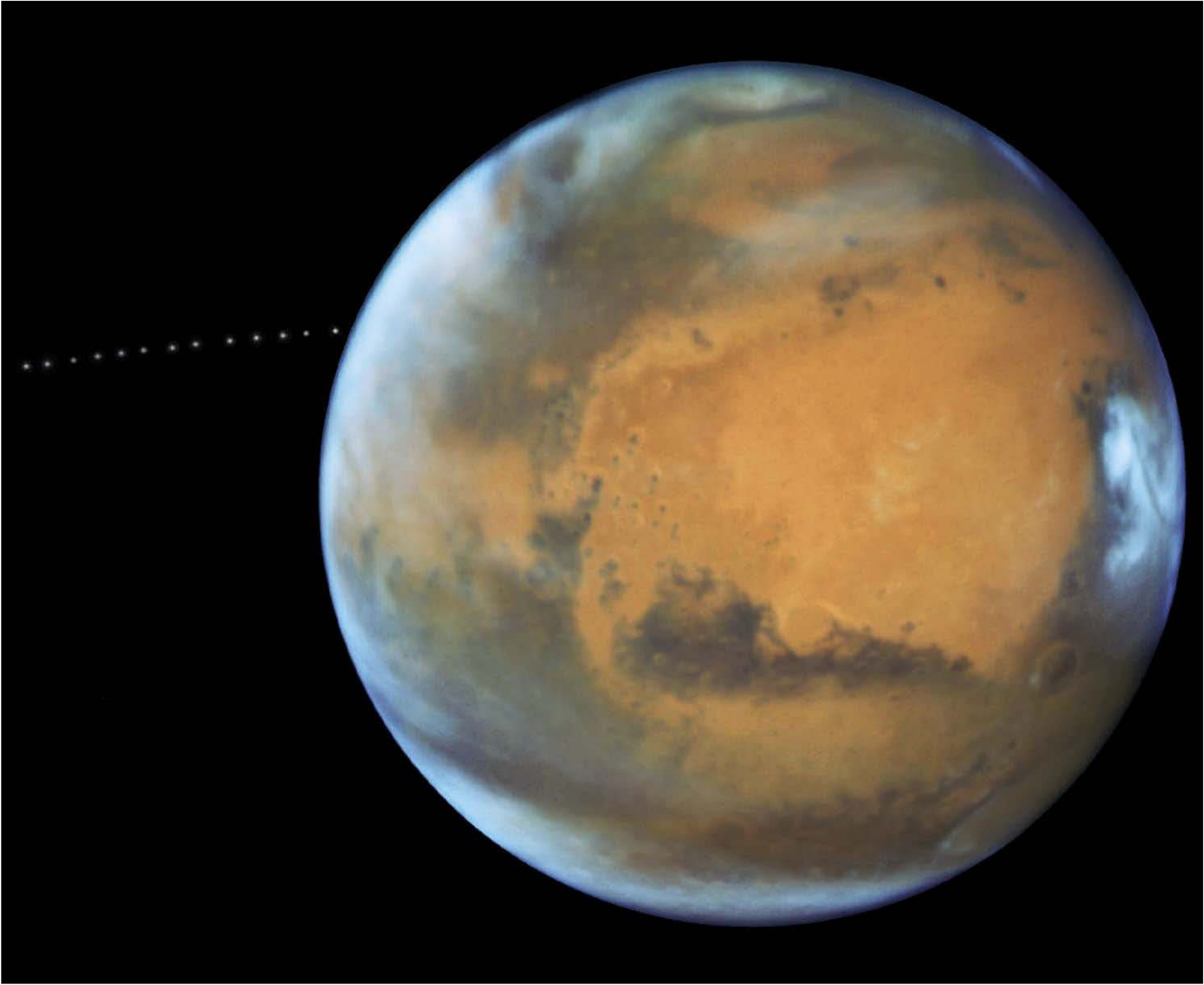
When this image was taken, Juno was 9,886km above the planet's cloud tops. The view shows a tempestuous atmosphere and provides a glimpse of the stormy conditions on Jupiter. It is a detail of a larger image that was processed by citizen scientist Kevin Gill, who used raw data captured by Juno that was made available to the public on NASA's Juno website (www.missionjuno.swri.edu).

Zooming in on the Great Red Spot shows the whorls of the storm in detail, but also a certain amount of graininess in the final image. This is because JunoCam captures images that are about 1,600 pixels wide, a relatively low resolution. Nevertheless, this image is the best close-up of the Great Red Spot ever achieved, and a testament to the success of the Juno mission so far.

Ultimately, the purpose of Juno is to follow up and delve deep where Voyager scratched the surface. Its goal is to help scientists understand the formation and evolution of the planet by analyzing its core, magnetic field, its atmosphere and aurorae. Juno launched in August 2011, finally arriving at Jupiter in July 2016, and is scheduled to end its mission in February 2018 by deorbiting into the planet.

YOUR BONUS CONTENT A gallery of these and more stunning space images





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▲ Phobos photobomb

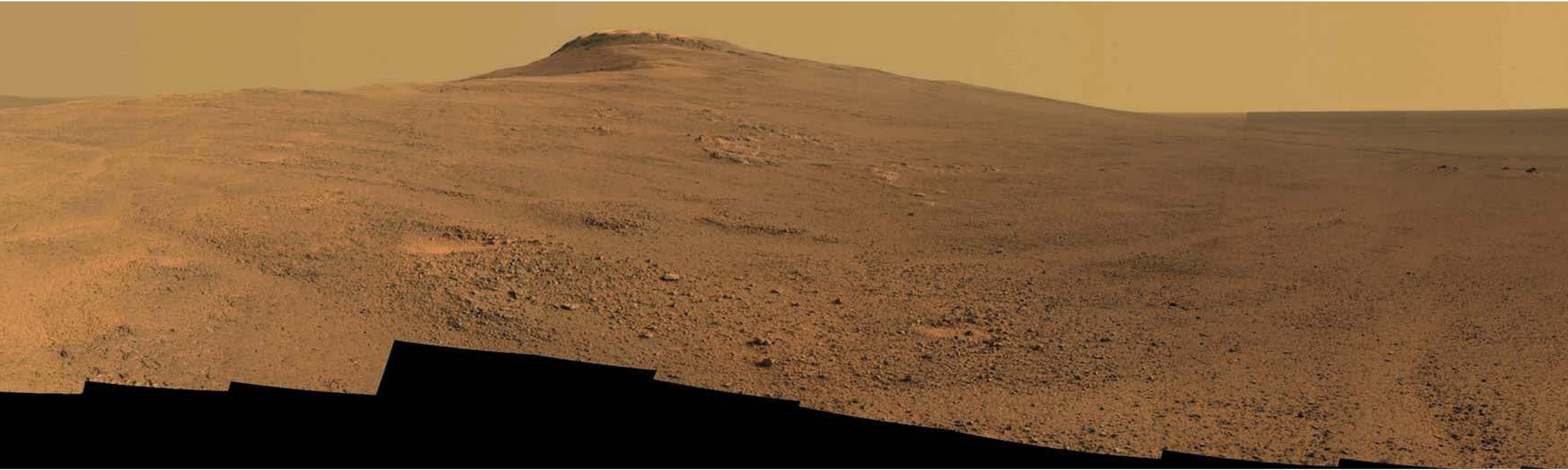
HUBBLE SPACE TELESCOPE, 20 JULY 2017

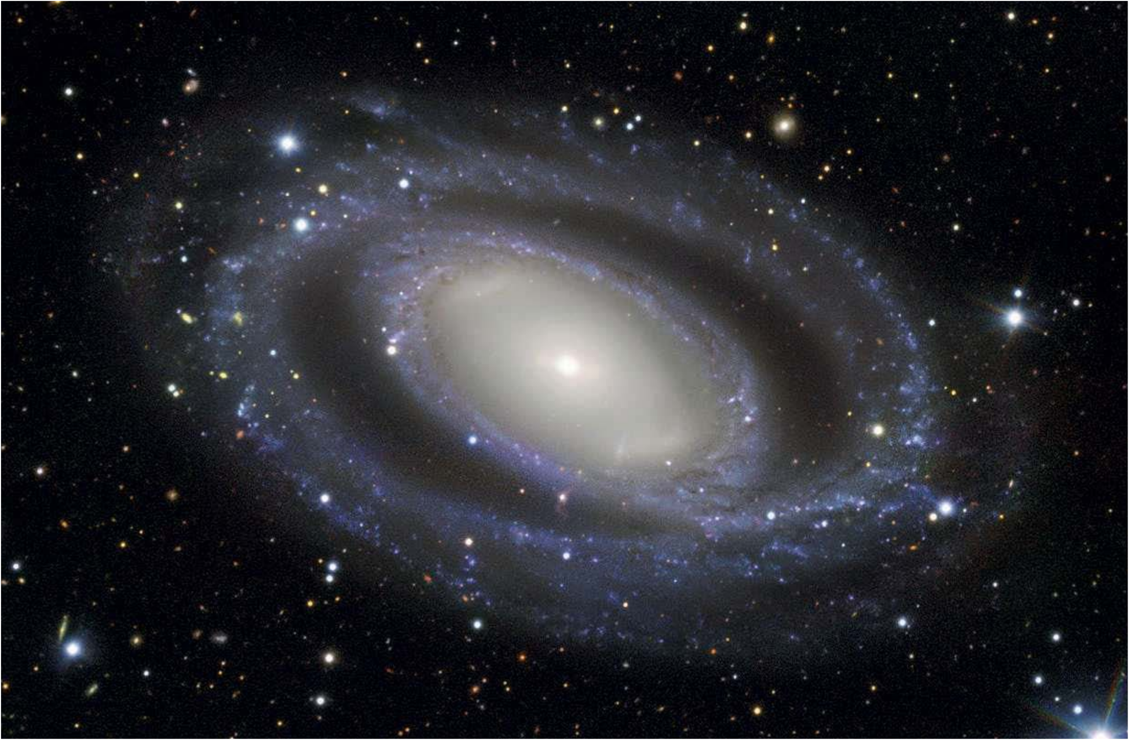
Astronomers were capturing images of Mars when they happened to spot the moon Phobos appearing from behind the Red Planet. Thirteen images taken over 22 minutes reveal the moon's motion as it orbits Mars, which it does every seven hours and 39 minutes. Phobos is edging closer to Mars with each orbit, and it is predicted that in 30-50 million years it may eventually crash into the planet.

▼ Perseverance is key

MARS EXPLORATION ROVER OPPORTUNITY, 7-19 JUNE 2017

This incredible view of the Martian landscape is a panorama above Perseverance Valley in the Endeavour Crater, captured by the Opportunity rover. To the far right you can see tracks left by the rover in the spring of this year. The rover is currently investigating the area to provide clues as to whether the valley was carved out by liquid water in the past.





◀ Galactic double ring

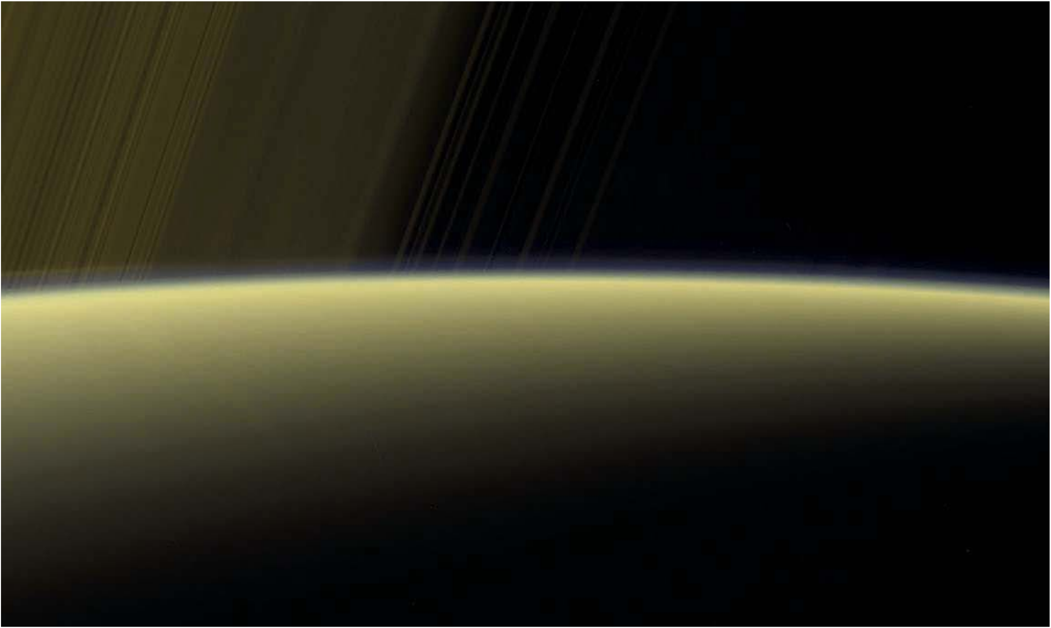
VERY LARGE TELESCOPE, 24 JULY 2017

Galaxy NGC 7098 is an unusual-looking spiral galaxy, in that its arms form two distinct rings. As well as this, the galaxy has developed two ansae, which are the bright areas of stellar density seen at the top and bottom of the central region. These can be found at either end of the central bar in some galaxies, although their exact origin is not known for sure.

Saturn's hazy horizon ▶

CASSINI SPACECRAFT, 16 JULY 2017

Haze on the limb of Saturn gives a view of the atmosphere into which the Cassini spacecraft will plunge when it ends its mission on 15 September 2017. This image captured by Cassini also shows Saturn's rings rising above the planet's horizon. The spacecraft is likely to lose contact with Earth before it reaches the depths of the haze.



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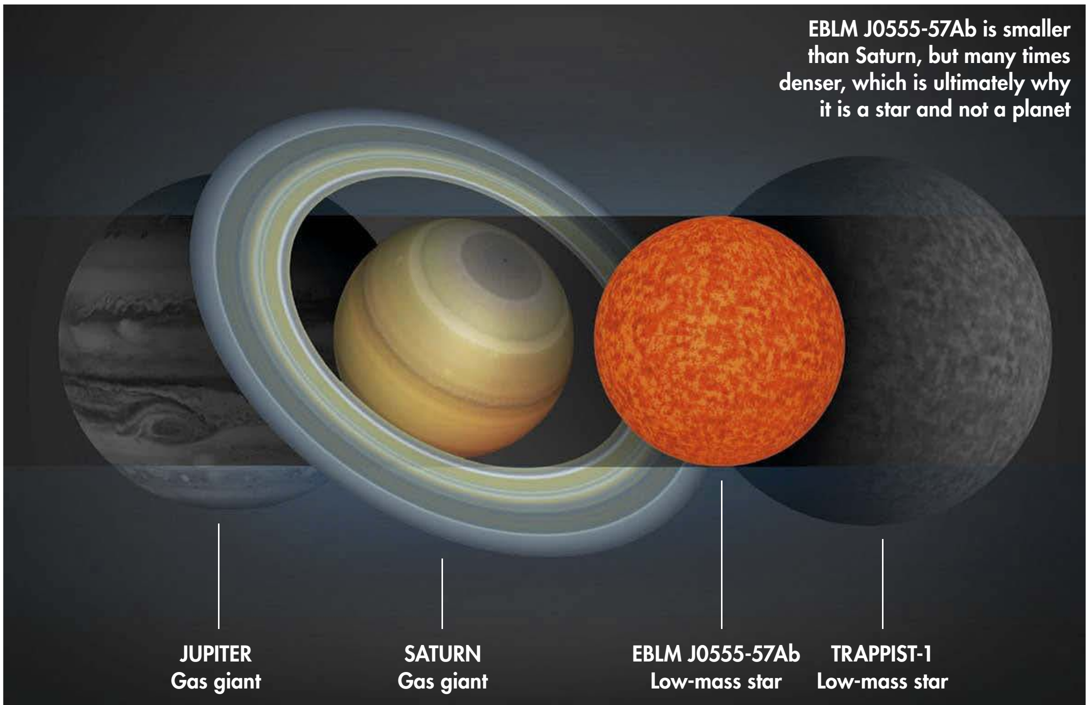
Our experts examine the hottest new astronomy research papers



EBLM J0555-57Ab is smaller than Saturn, but many times denser, which is ultimately why it is a star and not a planet

AMANDA SMITH/UNIVERSITY OF CAMBRIDGE

Smallest star ever DISCOVERED

Red dwarf found by planet hunters examining another star

The tiniest star ever observed, with a diameter slightly larger than Saturn, has been discovered 600 lightyears away. EBLM J0555-57Ab, a red dwarf in a binary system, was found by researchers on the WASP exoplanet hunting experiment, who were looking for planets passing in front of a larger star now thought to be its stellar companion.

"Our discovery reveals how small stars can be," says Alexander von Boetticher, the lead author of the study, from Cambridge's Cavendish Laboratory and Institute of Astronomy. "Had this star formed with only a slightly lower mass, the fusion reaction of hydrogen in its core could not be sustained, and the star would instead have transformed into a brown dwarf."

Red dwarfs are thought to be fertile grounds for exoplanet hunters, as the dim light of the star not only makes it easier to find planets, but also means that features caused by potential atmospheres will stand out and can be measured. Last year it was announced that red dwarf TRAPPIST-1, which is only 30 per cent larger than EBLM J0555-57Ab, is surrounded by seven Earth-sized worlds.

Despite their importance, little is known about red dwarfs. Although stars with masses less than 20 per cent of the Sun are the most numerous in the Universe, their weak light output makes them incredibly difficult to find.

"This star is smaller and likely colder than many of the gas giant exoplanets that have so far been identified," says von Boetticher. "It might sound incredible, but finding a star can at times be harder than finding a planet."

▸ **See Comment, right**

COMMENT

by Chris Lintott

This new star is smaller than Saturn, but the team estimate it has the mass of 85 Jupiters. That makes this one of the densest objects known – not quite up there with neutron stars and black holes, but ahead of almost everything else.

That density is why this is a star not a planet. At the surface the star is nearly as hot as the Sun, and at the star's core the temperature is high enough for the nuclear fusion of hydrogen into helium to proceed. That's about as close to a sensible dividing line between star and planet as there is. Large planets like Jupiter do produce some internal heat, but are nowhere near hot enough for hydrogen fusion.

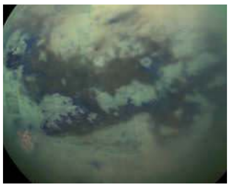
The importance of EBLM J0555-57Ab is that it lies very close to what's supposed to be the theoretical minimum, a mass equivalent to 83 Jupiters. Weigh in at anything less than that, and your chance of stardom is gone.

CHRIS LINTOTT co-presents *The Sky at Night*

NEWS IN BRIEF

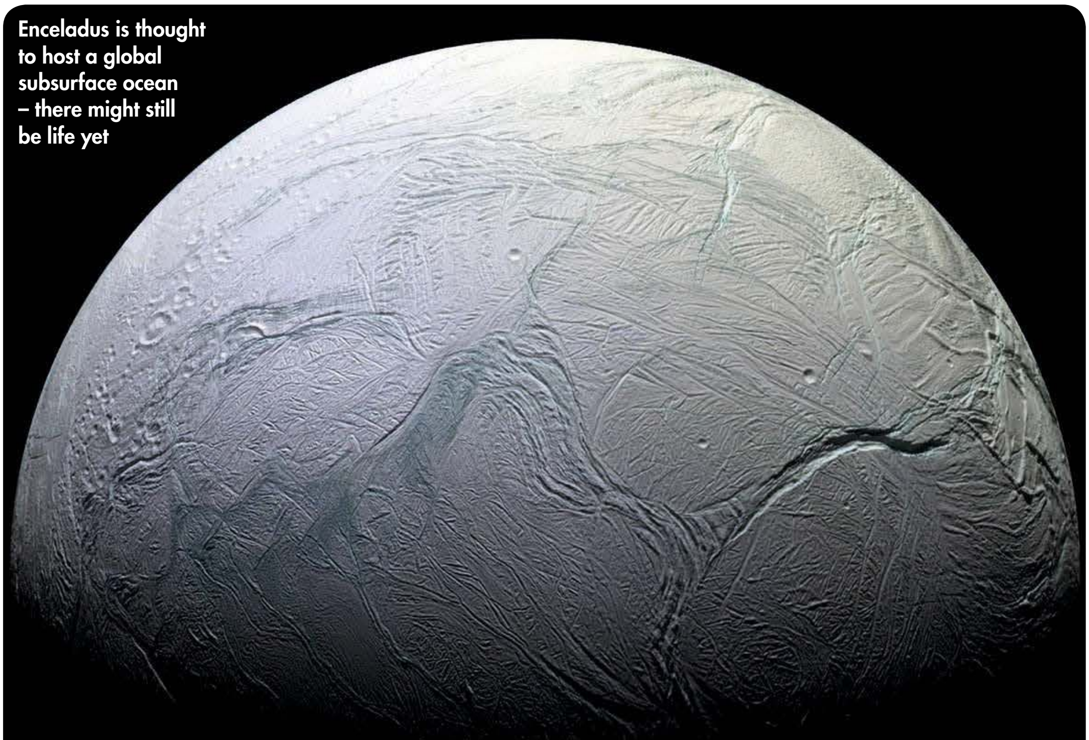
UK BOOSTS SPACE SECTOR

The UK government has pledged over £100 million to grow the nation's satellite production industry. Most of the money will be used to extend the National Satellite Testing Facility in Oxfordshire, with additional funding going to a rocket motor production and testing centre in Wescott, Buckinghamshire. "Having access to a National Satellite Facility will help companies develop and encourage new business to come to the UK," says Graham Turnock, chief executive of the UK Space Agency.



TINY WAVES, TINY WINDS?

The waves on the methane lakes of Saturn's moon Titan are only 1cm high, according to the latest research on Cassini images. It's encouraging news for those hoping for a future mission to the moon. "There's a lot of interest in one day sending probes to the lakes, and when that's done, you want to have a safe landing, and you don't want a lot of wind. Our study shows that because the waves aren't very high, the winds are likely low," says Cyril Grima from the University of Texas, who led the study.



Enceladus is thought to host a global subsurface ocean – there might still be life yet

Surprise methanol found around Enceladus

Suggestions that the molecule might signify life now seem unlikely

Methanol has been detected at Enceladus from Earth for the first time, a finding that suggests the chemical may not be an indicator for extraterrestrial life after all.

It was NASA's Cassini spacecraft that revealed the water plumes that erupt from this moon of Saturn and feed into the planet's E ring were rich in methanol, but at a level so low it could not be detected from Earth. Detection from terra firma – made by researchers looking for completely different molecules using the IRAM 30m millimetre radio telescope in the Spanish Sierra Nevadas – implies there is much more of it than scientists had imagined.

"Recent discoveries that icy moons in our outer Solar System could host oceans of liquid water and ingredients for life have sparked exciting possibilities for their habitability," says Emily Drabek-Maunder from Cardiff University, who was part of the team. "But in this case, our findings suggest that methanol is being created by further chemical reactions once the plume is ejected into space, making it unlikely it is an indication for life on Enceladus," says Drabek-Maunder.

The researchers suggest that the unexpectedly large amount of methanol was either trapped by Saturn's magnetic field, or had spread further out into Saturn's E ring than expected. In both scenarios, the methanol is greater than what can be explained from the plumes alone.

"Observations aren't always straightforward. To interpret our results, we needed the wealth of information Cassini gave us about Enceladus's environment," says David Clements from Imperial College London, who was also on the team. "This study suggests a degree of caution needs to be taken when reporting on the presence of molecules that could be interpreted as evidence for life."

The ability to observe such complex chemistry from Earth will be a boon to astronomers hoping to continue their studies of the moon after the end of the Cassini mission on 15 September. To truly appreciate Enceladus, though, a more direct approach will be needed.

"To understand the complex chemistry in these subsurface oceans, we will need further direct observations by future spacecraft flying through Enceladus's plumes," says Drabek-Maunder.

www.iram-institute.org

RAL SPACE, NASA/JPL/UNIVERSITY OF ARIZONA/UNIVERSITY OF IDAHO, NASA/JPL/SPACE SCIENCE INSTITUTE, KORALJKA MUZICUNIVERSITY OF LISBON PORTUGAL/ALEKS SCHOLZ UNIVERSITY OF ST ANDREWS UK/RAINER SCHOEDEL UNIVERSITY OF GRANADA SPAIN/ INCENT GEERS UKATC/RAY JAYAWARDHANA YORK UNIVERSITY CANADA/JOANA ASCENSO UNIVERSITY OF LISBON UNIVERSITY OF PORTO PORTUGAL/ LUCAS CIEZA UNIVERSITY DIEGO PORTALES SANTIAGO CHILE, ESA–C. CARREAU, ILLUSTRATION BY ZHENYANG XIA/UW-MADISON COLLEGE OF ENGINEERING, UNIVERSITY OF HERTFORDSHIRE

Super-Earths excite at Tau Ceti

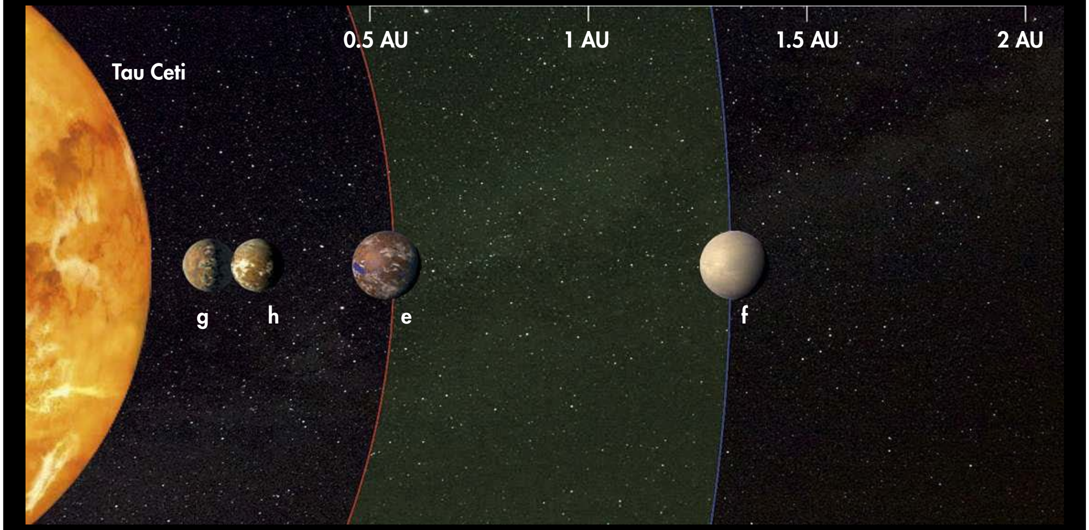
Four exciting new worlds have been found, two in the habitable zone

Four potentially habitable planets have been found around Tau Ceti, the closest Sun-like star to Earth at a mere 12 lightyears away. Two of them are in the star's habitable zone, the region where water could exist as a liquid.

With masses as low as 1.7 times that of Earth, they are the smallest planets ever detected around a Sun-like star. They were found by observing the wobbles they create in the movement of the star, but their diminutive size suggests that they are on the edge of what can be observed.

"Our detection of such weak wobbles is a milestone in the search for Earth analogues and the understanding of the Earth's habitability through comparison with these," says Fabo Feng from the University of Hertfordshire, who led the study.

www.herts.ac.uk



Two of the exoplanets (e and f) are thought to exist in the star's habitable zone, where water would be a liquid

The Milky Way's hidden masses

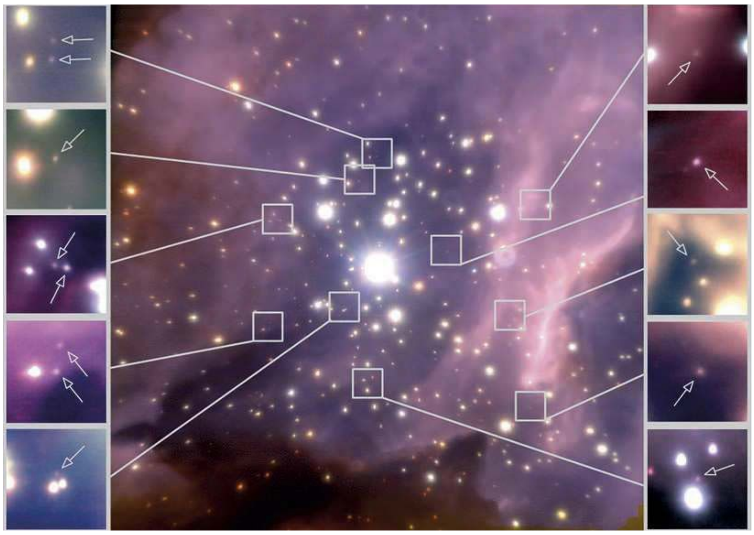
As many as 100 billion brown dwarfs may be hiding within the Milky Way, according to observations made with ESO's Very Large Telescope.

It's thought that brown dwarfs form in much the same way as stars, but lack the mass needed to kick start hydrogen fusion in their cores. This makes them difficult to spot as they don't emit much radiation.

A study of star cluster RCW 38 conducted in 2016 determined that it contained around one brown dwarf for every two stars. The finding corroborates previous observations from another cluster, one with a much lower density of massive stars, suggesting that the number of brown dwarfs is independent of the type of cluster they grew up in.

"We've found a lot of brown dwarfs in these clusters," says Aleks Scholz from the University of St Andrews. "Whatever the cluster type, the brown dwarfs are really common. Brown dwarfs form alongside stars in clusters, so our work suggests there are a huge number of brown dwarfs out there."

www.eso.org

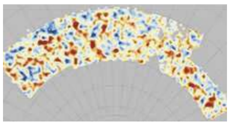


▲ The central 1.5 lightyears of RCW 38 and (inset) some of its faintest brown dwarfs

NEWS IN BRIEF

BEPICOLUMBO IN FINAL TESTS

The Mercury spacecraft BepiColumbo passed one of its last sets of tests in early July. The craft was configured as it will be for launch – with both orbiters, one built by Japan, the other by ESA, stacked on top of each other – then subjected to extreme vibrations and noise to ensure it will survive the beginning of its 7.2-year journey to the innermost planet. BepiColumbo will now undergo final thermal tests before being transported to French Guiana for launch in October 2018.



DARK MATTER MAPPED

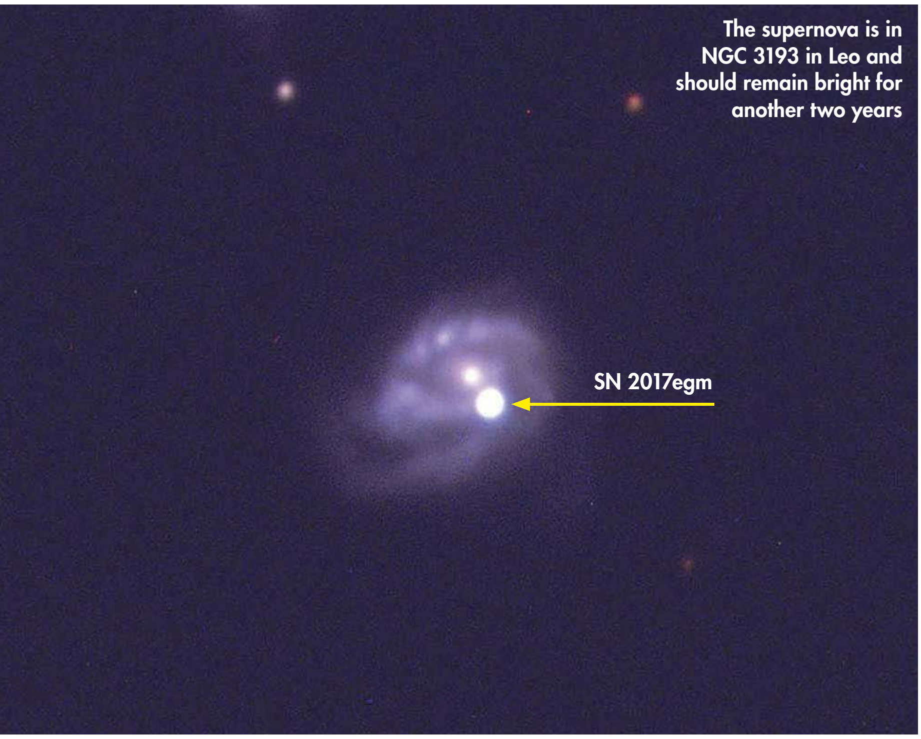
The most accurate map of dark matter has been released, helping to explain how the substance has shaped our Universe. It was created by analysing the light of 26 million galaxies using the first year of data from the Dark Energy Survey, a five-year project to investigate the role of dark matter and energy in the cosmos. Where previous dark matter studies looked back to 380,000 years after the Big Bang, this one observed how galaxies have changed over the past seven billion years.

CUTTING EDGE

Our experts examine the hottest new research

An exciting death

Supernova SN 2017egm is a rare 'superluminous' explosion – only 40 or so have ever been seen



The supernova is in NGC 3193 in Leo and should remain bright for another two years

STERNBERG ASTRONOMICAL INSTITUTE/MOSCOW UNIVERSITY

A supernova is always exciting, but one in a relatively nearby galaxy is even more so. Supernova SN 2017egm, which lit up nearby spiral NGC 3191 in May, is a spectacular and potentially important find, and not just because of its proximity to us.

At a distance of just over 400 million lightyears, it's not the closest supernova of the past few years, but it is the nearest example yet of a very special kind – the still mysterious 'superluminous supernova'. As the name suggests, these explosions are more powerful than their luminous counterparts, shining brightly and remaining visible for a long time after the initial explosion.

SN 2017egm was spotted on 23 May 2017 by the Gaia team; the Milky Way-mapping satellite had recorded the appearance of a star that wasn't there when it last looked in April. Swift work by a team at the Xinglong Station Observatory in the north of China just three days later seemed to suggest it was a Type II event, representing the death of a massive star, but further follow-up from telescopes in the Canaries and the US made clear it was destined to be a superluminous event. Previous supernovae of this type have been found exclusively in small, dwarf galaxies, but NGC 3191 is a massive spiral. Just by observing it, we've learnt something; these rare events (only 40 or so have ever been seen) can happen in massive galaxies, rich in elements other than hydrogen and helium produced by eons of vigorous star formation.

What's more, the thing is still bright. In a recent paper, a team led by Matt Nicholl of Harvard points out that while currently hidden behind the Sun, the slow fading of the supernova means it may remain bright enough for observation for another two years. Understanding that decay is essential if we want to understand what causes these unusual and powerful explosions; when we see light from a supernova, we're not seeing the explosion itself, but rather light released from the radioactive decay of elements produced in the initial maelstrom.

Watching the decay therefore helps us understand what happened right at the beginning, when a star in this galaxy reaches the end of its life and collapses in on itself. Its core will have become either a neutron star or a black hole, and both offer possibilities. Elsewhere in the Universe, at the centres of galaxies with growing black holes, the inflow of material onto an accretion disc surrounding the black hole produces energetic jets. Something similar could happen here, boosting the luminosity of the supernova. Or a newly created magnetar – a neutron star with a strong magnetic field – could be slowing down by interacting with its surroundings, pumping energy into its surroundings.

> ***"Watching the decay helps us understand what happened right at the beginning, when a star reaches the end of its life"***

Further study of SN 2017egm will help distinguish these models from each other, a unique opportunity presented by its proximity to us. Even after only a couple of months of observation, it's already a strong candidate for being the most exciting event to be observed this year.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

CHRIS LINTOTT was reading… *The superluminous supernova SN 2017egm in the nearby galaxy NGC 3191: a metal-rich environment can support a typical SLSN evolution* by Matt Nicholl et al.
Read it online at https://arxiv.org/abs/1706.08517

Milky Way has distant origins

Half of the Galaxy may have started a million lightyears from home

Half of the atoms that make up everything we know could have emigrated here from somewhere else

Fifty per cent of the atoms in this magazine, your body, and everything else in the Milky Way could have started life in another galaxy, according to the latest research into intergalactic winds.

These powerful streams blow at hundreds of kilometres per second between galaxies, transferring matter between them. New computer simulations have revealed that as much as half of the Milky Way's matter could have been brought into our Galaxy by this process.

"Our origins are much less local than we previously thought," says Prof Claude-André Faugher-Giguère, from Northwestern University and who took part in the research. "This study gives us a sense of how things around us are connected to distant objects in the sky."

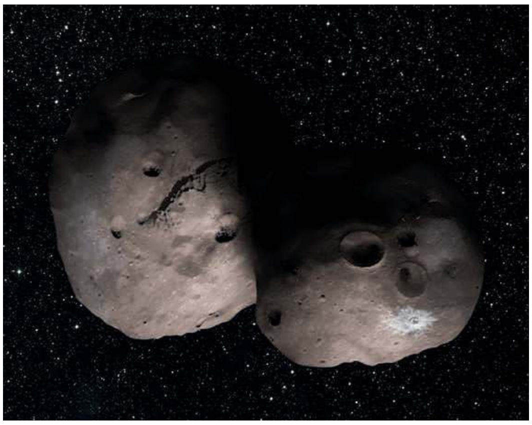
www.northwestern.edu

New Horizons asteroid may be a pair

NASA's New Horizons probe, which previously flew past Pluto, could be heading towards not just one target, but two. On 10 July its current destination, asteroid 2014 MU69, passed in front of a distant star. Observations of this occultation revealed that the space rock is either elongated or is in fact two bodies orbiting closely – perhaps even touching.

"This new finding is simply spectacular. The shape of MU69 is truly provocative, and could mean another first for New Horizons going to a binary object in the Kuiper Belt," says Alan Stern, New Horizons' principal investigator. "I could not be happier with the occultation results, which promise a scientific bonanza for the flyby."

www.sofia.usra.edu



▲ 2014 MU69 could be two space rocks posing as one, as illustrated here; alternatively, it could just be very long

LOOKING BACK THE SKY AT NIGHT

28 September 1976

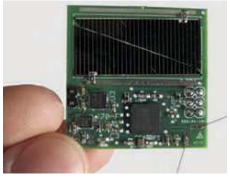
On 28 September 1976, *The Sky at Night* looked at the first science results from the Viking landers, the first probes to successfully touch down on the surface of Mars and send back data.

Two missions – both consisting of a lander and an orbiter – were sent to Mars and both made it to the Red Planet's surface. The orbiters managed to map all of Mars's surface to a resolution of 150m per pixel, the most complete view of the Red Planet at the time.

The landers were stationed on opposite sides of the planets. They sent back over 1,400 images of the surface, as well as conducting chemical, seismological and meteorological tests. One of these looked for living microbes on the planet and at first appeared to be positive. The result was quickly discounted as having a non-biological origin, though the debate over whether Viking detected life still continues over 40 years later.

▲ The Viking landers provided our first close glimpses of Martian terrain

NEWS IN BRIEF



SPRITES FIRED INTO ORBIT

The smallest ever satellite, weighing only 4g, has successfully made contact with the ground from low-Earth orbit. The tiny spacecraft, named Sprites, are only 3.5cm long yet contain a solar panel, radio transmitter and several sensors. They were developed for the Breakthrough Starshot project, which aims to send a fleet of nanospacecraft to Alpha Centauri within the next few decades.

PLANET HUNT AT BARNARD'S

A new planet hunt began on 16 July, when the Arecibo radio telescope turned its eyes towards Barnard's Star, the second closest star system to Earth after Alpha Centauri. There have been previous hints that a super-Earth planet exists in a 'cold' orbit far out from the star, beyond the habitable zone. The team will now scour the Arecibo data looking at the emissions from the star, such as those caused by flares. From these, the team will characterise the radiation and magnetic environment, looking for any perturbations that could be caused by planets.

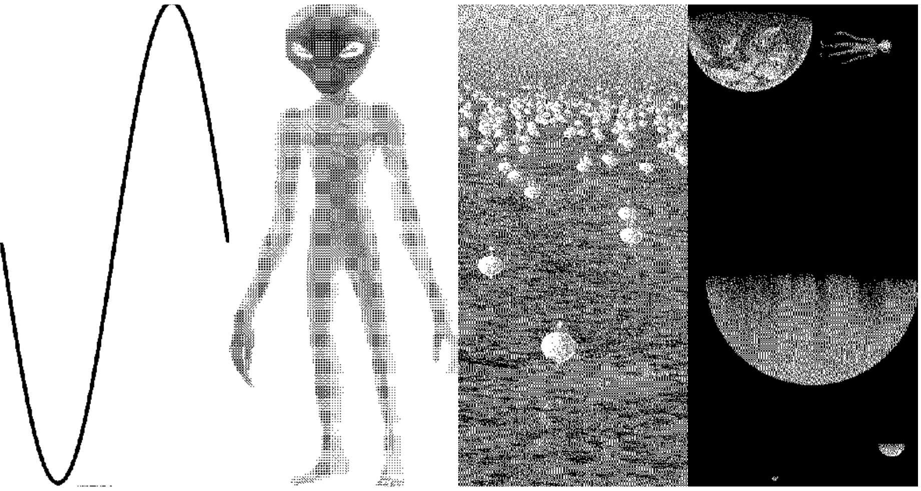
ESA/HUBBLE & NASA, NASA/JHUAPL/SWRI/ALEX PARKER, NASA/JPL, NASA/ESA/STSCI/G. BACON

CUTTING EDGE

Our experts examine the hottest new research

Citizen scientists could decode an alien message

The SETI Decrypt Challenge asked social media user to interpret an 'extraterrestrial' signal



RENÉ HELLER/SETI

▲ The final four pages of Heller's message – all vital information about the sender

The search for extraterrestrial intelligence (SETI) deals with the possible receipt of a message transmitted from an alien race and attempts to contact them with broadcasts of our own. But the key question is: would we be able to decode and understand any message we receive from the stars? Or, visa versa, how should we construct our own messages to make them easily understandable to extraterrestrial civilisations?

To explore this, René Heller at the Max Planck Institute for Solar System Research in Germany ran an experiment – the SETI Decrypt Challenge. He constructed a test interstellar message and released it to the internet to see if crowd-sourcing the solution could be effective.

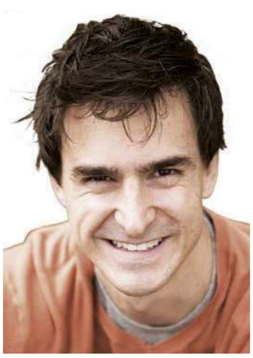
The message that Heller composed consisted of a sequence of almost two million bits (1s and 0s) the format that can be transmitted by a high-powered radio dish. It was also about a thousand times larger than the 'Arecibo message' transmitted towards globular cluster M13 from the Arecibo radio telescope in Puerto Rico in 1974.

Heller posted this message on social media, inviting anyone interested to have a go at deciphering it. He explained the scenario that this signal had been received from a star 50 lightyears away, transmitted at a radio frequency of 452.13 MHz. Within a month, he had received 66 correct solutions, about half of which were independent instances of the message having been cracked – the other half were based on help provided on public online discussion forums.

So what did this dummy SETI transmission consist of? The first clue in decoding this message comes from realising that the total number of bits – 1,902,341 – is the number that results from multiplying three prime numbers: seven, 359 and 756. Thus there are seven pages of data, each made up of a grid of binary numbers 359 wide by 757 tall. The first page contains just a frame of 1s to specify the size of the other six sheets. Page two defines the number system by counting up to 756, and page three lists the first 757 prime numbers – these establish that the message speaks in binary. Page four is an image of a sine function, just like the transmitted radio wave, with two numbers denoting the universal physical parameters of the Plank length and the Plank time. Taken together, this tells you the alien civilization knows that the Solar System is 50 lightyears from them; this is a direct message intended specifically for us. Page five is an image of the extraterrestrial species, with a header containing the information 2.45m and 180 years, their average height and lifespan. Page six is a picture of the transmitting radio dish, and the final image is of the alien homeworld with the number six billion years, the age of their planetary system.

> **"Any effort to decode a received alien message may indeed benefit from the collaborative efforts of amateurs"**

Heller says that the lesson learned from this test-run is that any effort to decode a received alien message may indeed benefit from the collaborative efforts of amateurs around the world, rather than a select few experts in a decryption team. And it's not just a numbers game; without any prior knowledge of the psychology or motivations of an alien race the chances of successfully understanding a message are greatly improved by involving people from a range of cultural and educational backgrounds.



LEWIS DARTNELL is an astrobiology researcher at the University of Westminster and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

LEWIS DARTNELL was reading… *Decryption of Messages from Extraterrestrial Intelligence Using the Power of Social Media – The SETI Decrypt Challenge* by René Heller

Read it online at https://arxiv.org/abs/1706.00653

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News & Events, September

Dark skies begin to return this month and now's the time to plan ahead for your autumn & winter observing. Check out the great new range from Sky-Watcher below, which you can now see in our Cambridgehire showroom, or at the Autumn Equinox Star Party at Kelling Heath (main day Saturday 23rd). See www.las-skycamp.org With the International Astronomy Show coming up on October 13-14th (see www.ukastroshow.com) there's lots to look forward to. As always, The Widescreen Centre will be there with new & best selling products and a host of very special offers. Come and see us soon.

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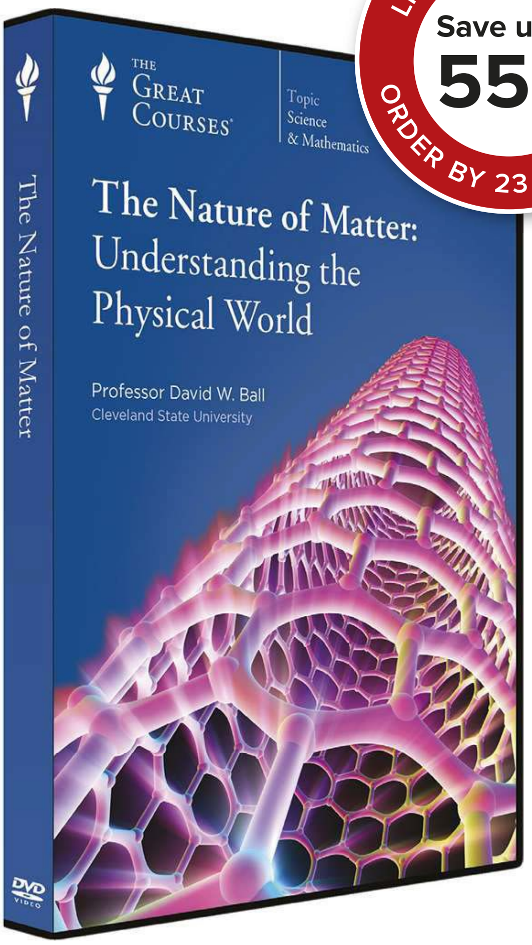

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12. Surface Energy: The Interfaces amongst Us
13. The Eloquent Chemistry of Carbon Compounds
14. Materials for Body Implants
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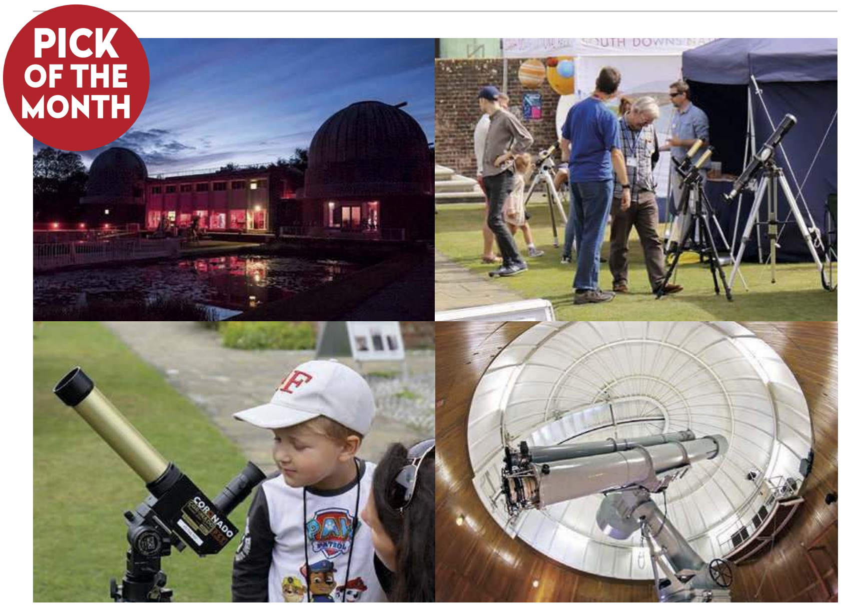
What's on

Our pick of the best events from around the UK

PICK OF THE MONTH



▲ **Get new perspective on the Solar System at this year's Herstmonceux extravaganza**

Herstmonceux Astronomy Festival 2017

The Observatory Science Centre, Herstmonceux, East Sussex, 1-3 September

The Herstmonceux Astronomy Festival, hosted in the beautiful former home of the Royal Observatory, is back with an exciting weekend for the whole family.

This year's talks will cover topics ranging from the Apollo missions to a potted history of the telescope and the anatomy of a solar eclipse, with speakers including former NASA Manned Space Flight Scientist David Baker and *The Sky at Night* presenters Pete Lawrence and Chris Lintott.

You'll also be able to look through historic telescopes, among them the observatory's Thompson 30-inch reflector, 13-inch astrograph and the Thompson 26-inch refractor. Planetarium shows and solar observing sessions will take place throughout the weekend, if you can draw yourself away from the trade stalls, raffles and compelling indoor and outdoor science exhibits. There will even be family workshops in which you build robots and pit them against each other.

For anyone wishing to camp under the backdrop of the iconic domes, there is a limited number of pitches available. There is alternative accommodation at Herstmonceux Castle, just a short walk from the Observatory Science Centre.

www.the-observatory.org/astronomy_festival_2017

BEHIND THE SCENES

THE SKY AT NIGHT IN SEPTEMBER

BBC Four, **10 September,** 10pm (first repeat **BBC** Four, **14 September,** 7.30pm)*

After 22 'deep dives' between Saturn's clouds and rings, Cassini will make a fatal plunge

CASSINI'S GRAND FINALE

On 15 September the Cassini probe will be purposely crashed into Saturn, ending its incredible 20-year mission. In this month's episode of *The Sky at Night*, Chris and Maggie look at Cassini's major discoveries and explore three ways in which the mission has changed the future of space exploration.

Check www.bbc.co.uk/skyatnight for subsequent repeat times

The UK's Beagle 2 Lander

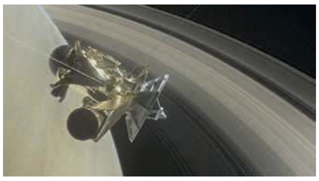
William Hulme's Grammar School, Springfield Road, Manchester, 11 September, 7pm

The Beagle 2 lander, the mission led by the late Prof Colin Pillinger, was sent to Mars to search for life in 2003 but lost communication with Earth on landing. In 2015, images captured by the Mars Reconnaissance Orbiter showed that Beagle 2 had in fact landed intact on the Red Planet. Dr Dean Harris explores this astonishing story of how the UK reached Mars. Entry is free.

www.wdas2.com

Cassini at Saturn

Stornoway Library, Cromwell Street, Stornoway, Isle of Lewis, 5 September, 7.30pm



Stornoway Astronomical Society hosts a talk exploring Cassini's mission to Saturn. Donny Mackay looks back on the launch and the spacecraft's arrival at the Saturn system, including a close look at the Huygens probe's landing on Titan. The talk will include many incredible photos of Saturn's rings and moons and summarise the findings of the past 13 years. Admission is free.

www.stornowayastro.org

Gravitational Waves: An Update

Dept of Physics & Astronomy, Cardiff University, 15 September, 7.30pm

Gravitational waves are ripples in the fabric of spacetime, and further evidence supporting Einstein's general theory of relativity. Patrick Sutton, a member of LIGO, gives a fascinating talk at Cardiff Astronomical Society about the progress so far and what these remnants of some of the most violent processes in the Universe mean.

www.cardiff-astronomical-society.co.uk

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.

What's on

Browse the latest astronomy events from around the country with our What's On database. Search your region for AS meetings, open evenings, star parties and more or add your own event by completing the simple Submission Form at the bottom of the page

All Events

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Quadrantid Meteor Observing
Norman Lockyer Observatory
Thu Jan 3, 2013

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The Infinity breaks the barrier between visual observing and astrophotography. It combines the experience of observing at the eyepiece with a level of depth and detail that would traditionally be the result of several hours processing. This takes a camera that's sensitive enough to capture faint details on distant objects, and fast enough to do it in real time. It then takes our powerful, intuitive software to bring stunning views of the night sky to a screen in just seconds.

This recreates the feel of observing in the field through a very large telescope, only using much more modest equipment. You stay connected to the night sky, watching satellites drift across your field of view, while viewing objects previously out of reach to all but the most powerful eyepieces and the largest apertures.

See the faint connecting filaments in M51 while planning your next move in your star atlas. See bok globules in the Pelican Nebula as you dodge the clouds. Dive deep into the NGCs of Andromeda - and do it all in colour.

Although our eyes aren't sensitive enough to see the universe in colour, the Infinity is. Faint grey fuzzies become detailed areas of colourful nebulosity, allowing you to go beyond the limits of our vision.

But our own vision isn't our only limitation. Light pollution is a growing problem for all of us, with backyard observing becoming increasingly difficult in many places. The Infinity helps you cut through the pollution to bring observing back to our urban areas.

It also helps you share the breath-taking things we see and discover as astronomers. By cutting the queue to the eyepiece, the Infinity allows everyone to explore the night sky not just together, but at the same time. You can discuss details and anomalies as you see them, and remove the need for special skills in averted vision.

This makes it the perfect tool for public outreach, as well as observing with family and friends. But the Infinity doesn't just provide you with incredible live views. It also allows you to save single images and even whole sessions to share later. You can even broadcast your session live online to a global audience, right from inside our software.

But surely something this advanced involves additional specialist equipment and complex software? That's the best bit. The Infinity is designed to work from a focal length of around 300mm right through to 1500mm. It works with alt/az fork-mounted telescopes as well as equatorial mounts. As long as you can track a star for a few seconds, it will work with an Infinity, without the need for complicated guiding systems.

The camera itself uses the latest in CCD technology to provide incredible sensitivity at very low noise, and it's all controlled through our custom built software. You want to spend your time exploring the universe, not learning our program, so we've kept it as simple and intuitive as possible while still giving you the power and control you need to delve deep into the night sky.

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A PASSION FOR SPACE

with **Maggie Aderin-Pocock**

The Sky at Night presenter hunts for space rocks not on Antarctica, but on a roof in Sidmouth

▲ **Maggie climbed onto the roof of the Norman Lockyer Observatory to search for tiny micrometeorites in the detritus collecting there**

It's classic thriller movie material: a comet or asteroid is heading straight for Earth and only one person can save us. In reality, however, the majority of stuff that lands on Earth from space is really quite small and does us no harm at all. It may even have been the precursor to life on the planet.

Some 40,000 tonnes of space rock lands on Earth every year, in a range of size – scientists often make pilgrimages to far-flung corners of the Earth to find specimens. Antarctica is good spot: metal meteorites that have been burnt by our atmosphere stand out nicely against the sheer white expanse of the ice sheets. It sounds like an ideal place to look, so why was I looking on the roof of Sidmouth's Norman Lockyer Observatory instead?

Well it turns out that although you get better contrast searching for meteorites in the snowy expanses, micrometeorites or space dust falls everywhere. So looking for it on a large, flat undisturbed roof is actually a good place to start – though it still feels like a long shot. I am told by my hunting guide Matt Genge not to expect much: he usually totals around 10 micrometeorites per 30kg of roof muck.

Sludge science

We collect about a dessert spoon's worth, so I'm not holding my breath. The sludge we've gathered is dried in a conventional oven, then a magnet is passed over it to pick up any magnetic material it might contain. The stuff we end up with is attached to some double sided sticky tape and then analysed using a semi-portable scanning electron microscope.

Matt helps me to home in on any potential candidate micrometeorite particles: we are looking for material with high density and a regular spherical shape. We see a few objects that fit the bill and zoom in, increasing the magnification from 40 times to 5,000 times.

At this level of magnification we can see spherical bead-like structures with a tapered cone at one end. This fits the description of a micrometeorite but it is small – just 10μm in diameter, less than the diameter of a human hair As the micrometeorites hit our atmosphere they heat and melt, forming a droplet of molten metal. As these fall through our atmosphere they cool, forming dendritic crystalline structures that look like feathers. The cone is formed due to friction with the air.

There's still one last check to make: some pollution from smelting plants and similar processes can look like our potential micrometeorite. So with the microscope we do a chemical analysis, and this gives us more evidence that we have found some space dust. Matt is 95 per cent certain that this is a micrometeorite.

I am still looking forward one day to getting out to Antarctica and looking for meteorites there, but to have found space dust just by looking on a roof in the UK, to me, seems quite amazing.

Maggie Aderin-Pocock co-presents *The Sky at Night* and *CBeebies Stargazing*

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You may think that the best way to explore the wonders of the universe would be to hop aboard a spaceship. In fact, you can now do it aboard a cruise ship! There are now a number of itineraries showcasing the glories of the universe as well as wonders of a more terrestrial kind.

Astronomy heaven

La Palma in the Canary Islands is home to the world's largest single-aperture optical telescope, Gran Telescopio Canarias. Perched on a 7,500-foot volcanic peak, its giant mirror is deemed to offer some of the best views of the universe in the northern hemisphere. You'll have the option to tour the facility during Saga Sapphire's Canary Island Constellations cruise early next year.

The ship's Captain, Julian Burgess says: "Witnessing the Milky Way blazing through a multitude of stars above La Palma is unforgettable. You'll also enjoy talks from several experts on board, including the chief astronomer of Northumberland's Kielder Observatory, Gary Fides, and space flight historian Howard Parkin."

Seek out the Northern Lights

Cruising is also a great way to search for the aurora borealis, and Saga Pearl II's Bright Lights in Norway itinerary will be in just the right place at the right time. Head Cruise Planner James Langley explains: "During our overnight stay in Alta, an expert guide will lead you into the Arctic wilderness on an included excursion. Here you'll find a cosy campfire, miles from any light pollution, and hopefully the lights will appear."

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- January 7, 2018 from Southampton
- 14 nights all inclusive# aboard Saga Sapphire.

Bright Lights in Norway
- February 14, 2018 from Portsmouth
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For more details, call Saga **FREE** on **0800 056 9947** quoting **SKY24** or visit saga.co.uk/cruise

Pictured clockwise from top: Stargazing in the Canaries; Captain Julian Burgess at sea; Saga Pearl II in picturesque Norway.

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JON CULSHAW'S

EXOPLANET EXCURSIONS

Jon explores an ancient planetary system and its close-knit companions

Sir Patrick Moore frequently spoke of the unfathomably huge distances and enormous spans of time involved in astronomy, far beyond the parameters we would ordinarily deal with as human beings. But as he said, "Nevertheless, we simply have to accept them."

The system we're visiting this month is believed to be 11.2 billion years old. At around 80 per cent the age of the Universe, Kepler 444 is the oldest planetary system that we know of. It centres on an ancient red star and formed when our Galaxy was a mere toddler at just two billion years old, proving stable planetary systems formed very early on in the history of the Milky Way.

You can see mag. +8.9 Kepler 444 from Earth with a small telescope or binoculars: it is 117 lightyears away in the constellation of Lyra. But I'm piloting my ship closer, to the outer limits of the system, to see if its great age has resulted in a situation of settled calm or instead, perpetual chaos and orbital eccentricity.

There are five planets orbiting this star. All are terrestrial and smaller than Earth, ranging in size from Mercury to Venus. Kepler 444b is the smallest and completes an orbit in 3.6 days at a distance of 0.04 AU. My observing point is nestled at the side of Kepler 444f, the largest and outer planet of the system. Despite being the farthest out, it's still relatively close to its home star at only 0.08 AU, making one orbit in just under 10 days.

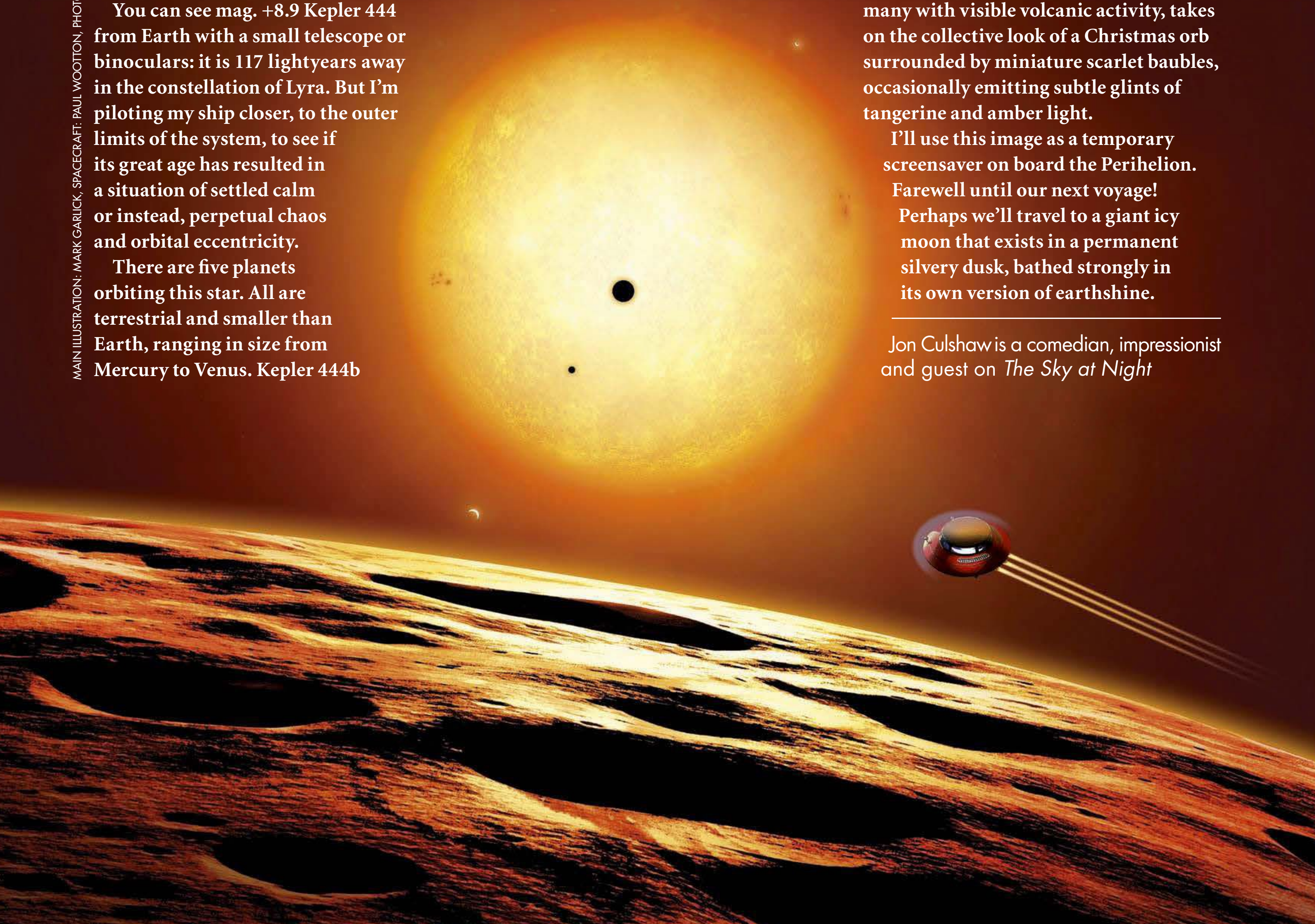
Being so close to their star, all of these planets are far too hot to support life as we know it. I decide to make a cautious landing on the surface of the dark, cooler side of Kepler 444f. There's a sobering sense of age on the surface of this world. Stepping out onto those oldest surfaces of lava and igneous rock brings a sense of deep, deep time that makes Stonehenge seem like a new-build garden installation at a Wetherspoon's pub.

The lack of atmosphere makes for a jet-black sky festooned with thousands of stars in unfamiliar constellations. Letting my imagination construct some asterisms of its own, in a few minutes I've created a triceratops, a TARDIS and the Angel of the North.

Launching from the surface of Kepler 444f and making a looping fly-past so all planets come into view, it's amazing to see what a tight, compact system this is: reminiscent of a Pocketeer maze game, with its concentric ball bearings whizzing round a central circle. The soft shimmer of Kepler 444 and its planets close by, many with visible volcanic activity, takes on the collective look of a Christmas orb surrounded by miniature scarlet baubles, occasionally emitting subtle glints of tangerine and amber light.

I'll use this image as a temporary screensaver on board the Perihelion. Farewell until our next voyage! Perhaps we'll travel to a giant icy moon that exists in a permanent silvery dusk, bathed strongly in its own version of earthshine.

Jon Culshaw is a comedian, impressionist and guest on The Sky at Night



MAIN ILLUSTRATION: MARK GARLICK, SPACECRAFT: PAUL WOOTTON, PHOTO: EMMA SAMMS

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Email us at **inbox@skyatnightmagazine.com**

This month's top prize: four Philip's books

PHILIP'S The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philips: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Robin Scagell and David Frydman's *Stargazing with Binoculars* and Heather Couper and Nigel Henbest's *2018 Stargazing.*

Tales from THE EYEPIECE

Stories and strange tales from the world of amateur astronomy by Jonathan Powell

"For many years, when my turn came to look through the eyepiece when observing in a group I became flustered: fumbling to remove my glasses, let alone knowing where to put them, followed by the banging of the bridge of my nose on the eyepiece, then squinting at an object that was out of focus and just about to leave the field of view. Many times I would say that I had seen the object to avoid embarrassment, but in truth I hadn't, and it was highly frustrating. Decades on, with motor drives keeping a constant lock on an object, it isn't a problem – but the question of whether to take my glasses off remains a bone of contention. For me it's off, quickly followed by "where did I put my glasses?" and the realisation that I might have left them where someone else is now sitting!"

Jonathan Powell is the astronomy correspondent for the South Wales Argus

MESSAGE OF THE MONTH

A Homeric eclipse

Michael beside the iconic statue of Odysseus at Ithaca harbour in Greece and (inset) a partial eclipse image he took in Turkey

I have been lucky enough to have chased six total solar eclipses round the world to date, and I hope to experience the US total solar eclipse at Idaho Falls on 21 August 2017. On my recent holiday to Greece in May 2017 I had the chance to visit the island of Ithaca, homeland of Odysseus, the hero of Homer's epic poem. I was intrigued to discover that in *The Odyssey*, an eclipse coincided with Odysseus's homecoming after a decade fighting the Trojan War and another 10 years voyaging home. Using NASA eclipse data, Greek geologists and physicists have narrowed this eclipse down to an annular eclipse that occurred on 30 October 1207 BC. In turn, this ancient eclipse research suggests that the Trojan War commenced in 1227 BC and ended in 1217 BC. No matter what anyone's circumstances are during an eclipse, we can be sure these events had a big influence in the time of Odysseus and of Homer. Any eclipses I see from now on will have a perspective of ancient history.

Michael Knowles, Mansfield

Some remarkable insight into one of the oldest works of Western literature, Michael. Good luck with your upcoming trip to the US! **– Ed**

Unexpected delights

I was just settling down on my sunlounger to go through Stephen Tonkin's Binocular Tour of Cepheus when a bright meteor raced up from the southern horizon past Vega. Looking at the star map I realised it must have come from the vicinity of Capricorn and being a couple of days off the maximum of the Alpha Capricornid meteor shower, I suspect it was one of them. To paraphrase Forest Gump – the night sky is like a box of chocolates – you never know what you are going to get!

Jeff Mason, Stockport

You're quite right Jeff: unexpected pleasures like bright meteors are one of the great things about this hobby of ours. **– Ed**

Tweets

Colin Whitman
@R30ColinWhitman • Jul 24
First attempt at photographing the #Milkyway coming out of my right chimney #Stars @newslineweather @barrabest @WeatherCee @angie_weather

SOCIETY in focus

▲ **The pupils also received copies of this magazine**

Pupils from Burdett-Coutts & Townshend Foundation CE Primary School (pictured) have been searching for stars as part of the Mayor's Fund for London initiative Discovery in a Week, organized by Russian philanthropist Yelena Baturina's charitable organization Noosphere.

Discovery in a Week brought together London primary and secondary school pupils with PhD astronomy undergraduates from University College London. Over the course of three days at City Hall, the children joined other pupils from London schools to learn about astronomy and look for new stars by accessing the 20-inch T31 telescope in Australia robotically. They were able to spend time on the telescope via the internet and analyse data to search for signs of undiscovered stars. They also joined schoolchildren from Moscow and professional astronomers via Skype to discuss and exchange ideas during the search.

During last year's initiative, another group of pupils from Hammersmith Academy discovered four new variable stars, which are classified as low-mass contact binary stars. They are all in the constellation of Centaurus, and have been recorded in the International Variable Star Index. They have been named Reynolds V1, Hamed V1, Mousa V1 and Mousa V2 after the pupils.

Each of the children from Hammersmith Academy received certificates from the International Astronomical Registry, documenting their role in the stars' discovery. You can search for the children's newly discovered stars at **www.aavso.org.**

Tweets

David Burlington
@19burly68 • Jul 21
pier taking shape @skyatnightmag

The origins of life

I was intrigued to read all about the theory that life on Earth came as a spark of life from matter outside our planet (Life from Space, July 2017). Thank you for explaining both sides of this complex argument and making me exercise my grey matter. I didn't come down on either side and I look forward to learning more in the magazine once further research is published.

Jennifer Shelden, Leicester

I'm glad you enjoyed the feature, Jennifer. It's a fascinating area to consider. ***– Ed***

Here's a crash course

Meteors and meteorites come in all shapes and sizes, so I'm wondering why they all produce perfectly round impact craters on every planet and moon they land on?

Brian Slack, Milton Keynes

Not all impact craters are round, Brian. Those that are are the result of an impact that explodes like a bomb, creating a circular crater that is many times larger than the original space rock. ***– Ed***

OOPS

- The Welcome note on page 3 of the August 2017 issue mentioned Blue Horizon instead of aerospace company Blue Origin.

- A caption on page 44 of our August 2017 issue, which said the rockets that launched the Shuttle burnt up in the atmosphere, was incorrect. It was the Shuttle's fuel tank that burnt up in the atmosphere; its solid rocket boosters fell back to Earth to be retrieved for reuse after each launch.

Meanwhile on FACEBOOK...

WE ASKED: Buzz Aldrin wants to send humans to Mars. Would you like to be one of the first settlers? What would you take with you?

Wayne Ryles
I'd certainly be up for it I'd take a large crate of beer, a guitar and a telescope so I could look back at the Earth and sing a rendition of Bowie's life on Mars.

Paula Attwood-Rees
I would love to go and be one of the pioneering Settlers. I would take my golf clubs because look at the size of those bunkers!

Tony Moss
My telescope as light pollution should not be a problem.

Adrian Strand
My hiking boots, adapted for my Mars suit to walk in that desolate but beautiful landscape.

Al Higgs
I would take a soil sample from Earth.

Shareen Ismail
No way, I'm too much of an outdoors person, give me fresh air and flowers any day.

Michael Marshall
Mashed potatoes.

Mike Perkins
I'd go as long as there was a good supply of cheese and bacon.

Michael Brown
Assuming that the mission sent the essentials for survival and sufficient computing power with an uplink to earth, I'd bring one home comfort to remind me of the family I leave behind, a toy Bagpuss. Besides that I would like to bring durable pressurised tents, freeze dried biomass for compost and seeds for a variety of tasty nutritious plants with low light requirements.

David Konstantinou
I would take some paint and brushes so I could be the first person to paint the first Martian landscape.

Dean Woodward
I'd take some spare fuel to get back.

Steven Pranckevicius
A photograph of Slough!

Chris Russell
The entire works of Mozart and my telescope.

Robb Crow
Sausage rolls.

James Schuck
Have to have trees and green rivers and snow so I think I'll stay on my home planet.

BBC

Sky at Night

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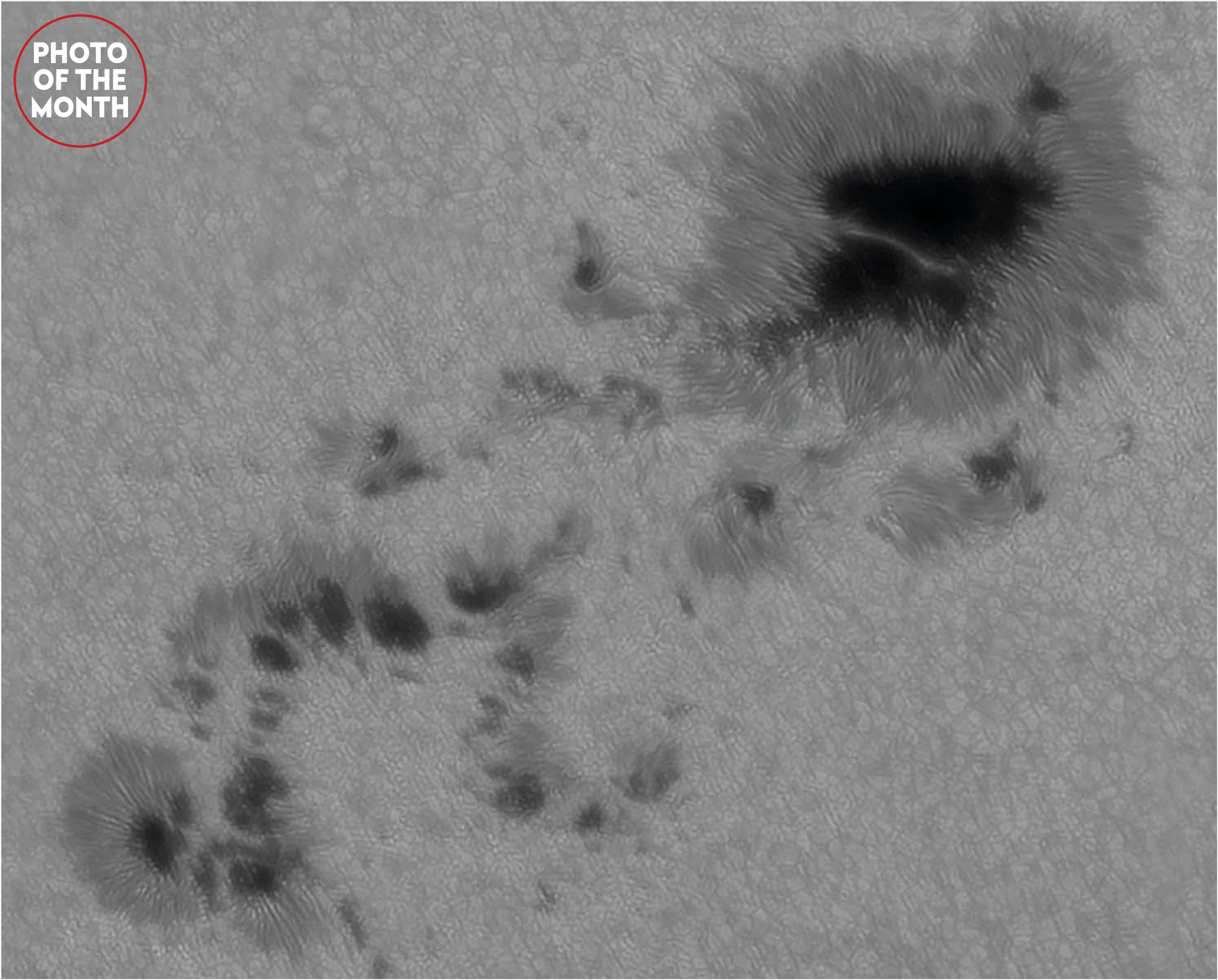
Hotshots

This month's pick of your very best astrophotos

YOUR BONUS CONTENT

A gallery containing these and more of your stunning images

PHOTO OF THE MONTH



▲ Sunspot region AR2665

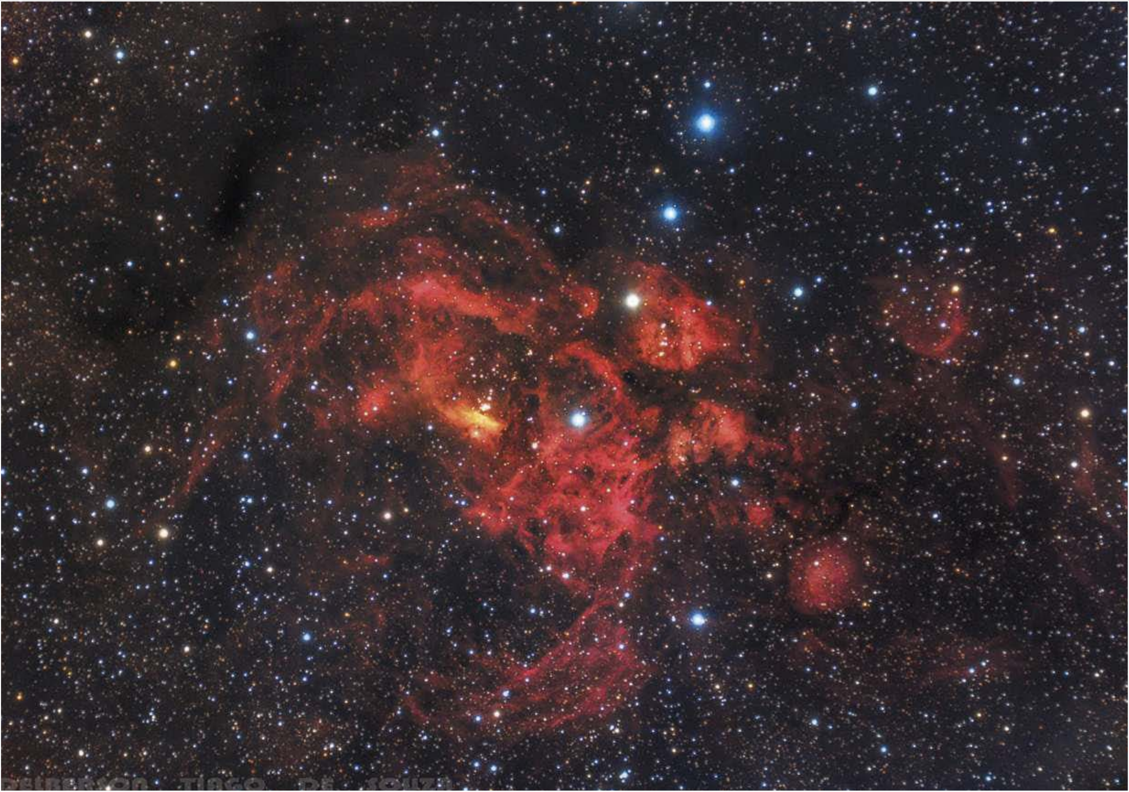
DAVID SEARLES, KENT, 9 JULY 2017

David says: "With the Sun heading towards solar minimum, this shot chose itself! It was just good to see some activity, the Sun having been quiet for a while. Working at a focal length of about 5m, achieving good focus is a big challenge as the daytime seeing can be quite variable."

Equipment: ZWO ASI120MM-S mono CMOS camera, Celestron CPC 925 XLT Schmidt-Cassegrain, 2x Barlow lens, white light filter.

***BBC Sky at Night Magazine* says:** "David has captured an incredible level of detail in this solar image, not just in the sunspot itself but also the texture on the surface of the Sun. Patience is a virtue in any solar imager, waiting for interesting and dynamic features to appear on the surface of our host star, and in David's case it has certainly paid off."

About David: "I've had an interest in astronomy since being a student back in the 1980s and got into astrophotography about seven years ago. I started with planetary, then deep-sky objects and most recently hydrogen-alpha and white light solar imaging. My particular interest in solar is in close-ups rather than full discs; hence the latest setup using my CPC 925. Imaging in white light at a 5m focal length is not the easiest, but I enjoy the challenge of getting decent data captured and the subsequent processing to get as much fine detail out as possible. The Sun is constantly changing so there is usually something of interest to image, though it is a shame we are now heading towards solar minimum."



◀ The Lobster Nebula

DELBERSON TIAGO DE SOUZA, SILVÂNIA, BRAZIL, 24 JUNE 2017

Delberson says: "The Lobster Nebula is very faint and it requires a careful imaging session and careful processing. It has so many details and great colours and deserves a well done job."

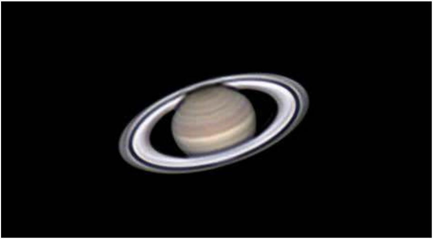
Equipment: QHY163M mono CCD camera, Orion ED80 apo refractor, Sky-Watcher HEQ5 Pro SynScan mount.

▼ Saturn

RONALD PIACENTI JR, BRASÍLIA, BRAZIL, 11 JUNE 2017

Ronald says: "The position of the planet was east at an altitude of 49°. There was some turbulence and the seeing was regular, but still I managed to capture an image I was pleased with. On previous attempts I had failed to capture this target."

Equipment: ZWO ASI120MC CMOS camera, Celestron C6 XLT Schmidt Cassegrain, Sky-Watcher HEQ5 Pro SynScan mount.

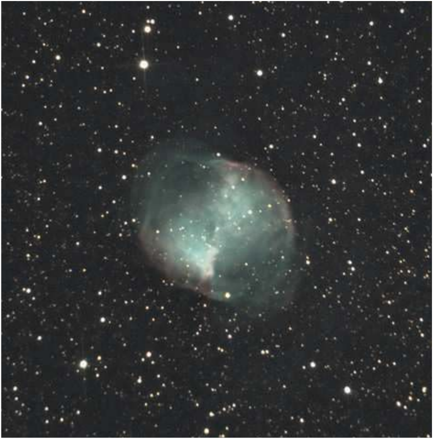


The Veil Nebula ▶

DAVID CANNON, HAMILTON, 17 JULY 2017

David says: "The only scope I have that can cover an area of this size is my 3-inch refractor. I have imaged parts of the nebula with larger scopes, but I wanted the whole nebula in one image. I was amazed how well it came out due to it being shot in summer from a light-polluted back garden."

Equipment: Canon EOS 60Da DSLR camera, Altair Astro Starwave 70ED triplet apo refractor, Sky-Watcher NEQ6 Pro SynScan mount.

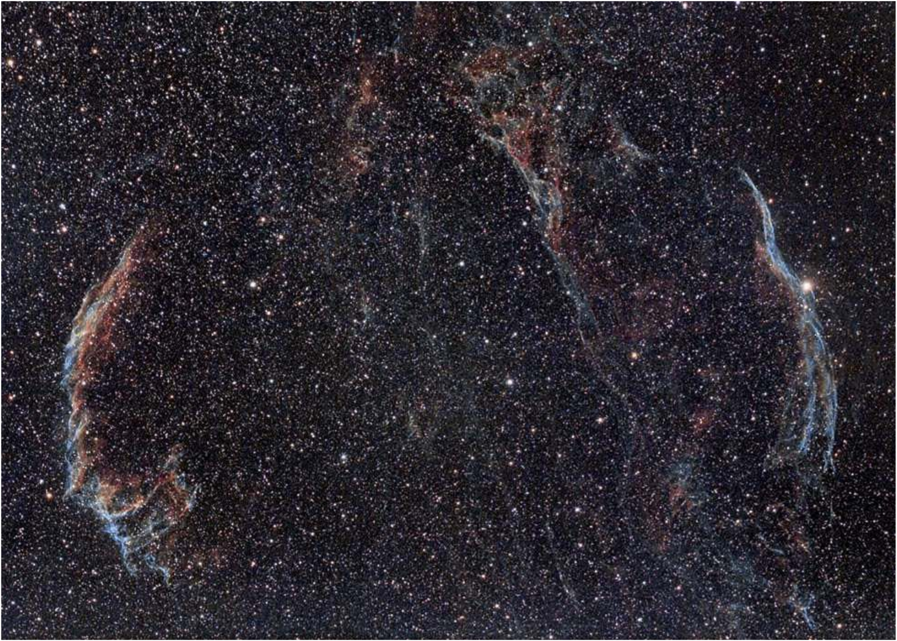


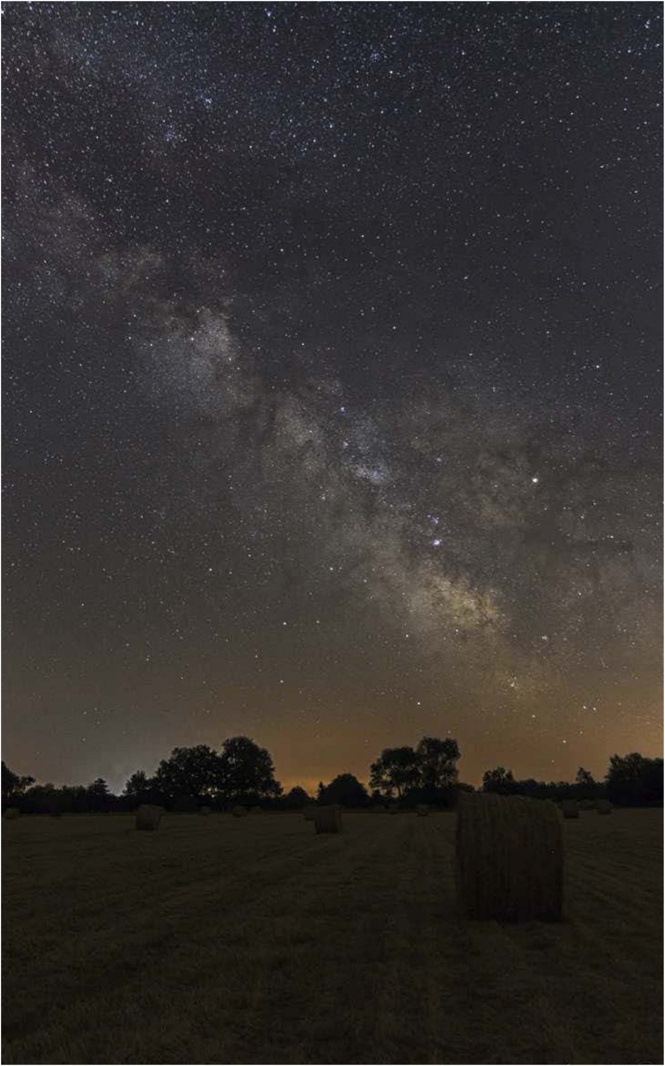
◀ The Dumbell Nebula

MATT DUNFORD, SHROPSHIRE, 18 JUNE 2017

Matt says: "The skies where I am are light polluted so I am limited in how far I can go with exposure. This was starting to overexpose, but I was able to bring it back in possessing. It was my first shoot with a guide camera and wow, what a difference it makes! I can't wait for some clear skies to get back out there, as the weather has been a let-down lately."

Equipment: Canon EOS 700D DSLR camera, Sky-Watcher Explorer-200P Newtonian, Sky-Watcher EQ5 Pro equatorial mount.



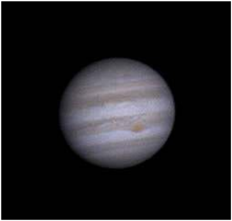


◀ The Milky Way

DAVID DE CUEVAS, TREIZE VENTS, FRANCE, 23 JUNE 2017

David says: "We had beautiful clear nights at the end of June and I took advantage by spending time walking around the countryside. I wanted to immortalise the early summer and the harvest by showing nature against the night sky."

Equipment: Canon EOS 700D DSLR camera, Sky-Watcher Star Adventurer mount, Tamron 17-50mm lens.



◀ Jupiter

HOUSSEM KSONTINI, TUNIS, TUNISIA, 4 JULY 2017

Houssem says: "Knowing that the Great Red Spot is bigger than Earth is just incredible, which is why I chose to shoot Jupiter when it was visible. I was excited to try my new camera, despite poor conditions. Fortunately, its high sensitivity and frame rate allowed me to get a good quality image."

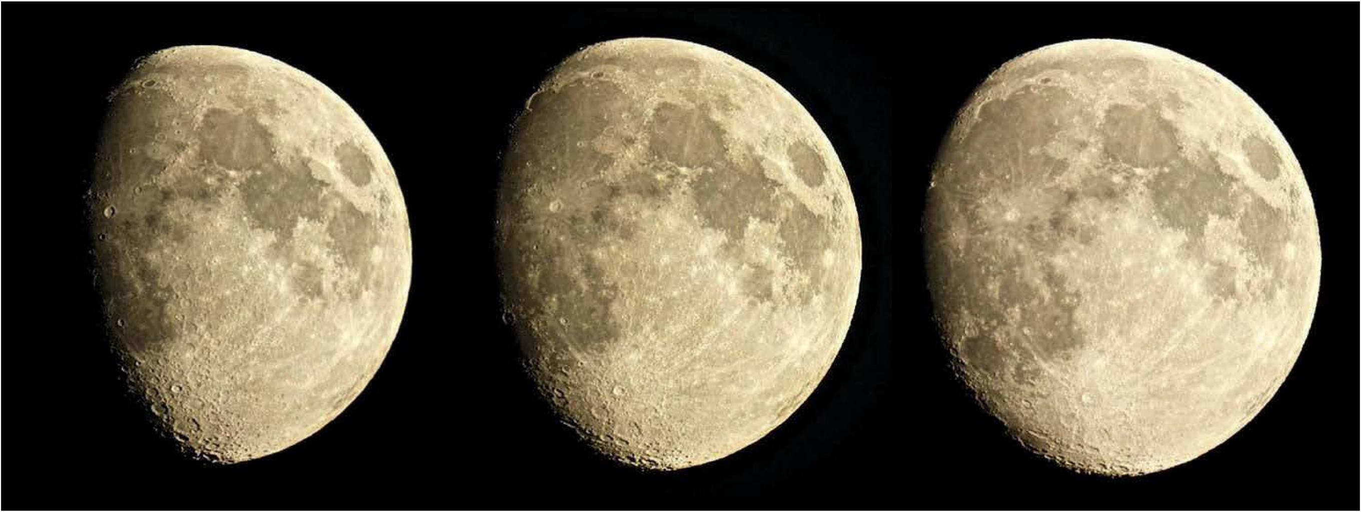
Equipment: ZWO ASI224MC CMOS camera, Sky-Watcher 150/750 Explorer reflector, Sky-Watcher NEQ3-2 mount.

▼ Moon montage

SARAH & SIMON FISHER, WORCESTERSHIRE, 3-5 JULY 2017

Sarah says: "The UK skies are usually quite changeable, but the seeing on these nights was outstanding. Each image is a prime focus single shot. This isn't the easiest technique to master, but we were thrilled with the results and decided to create a montage showing the waxing gibbous Moon."

Equipment: Canon EOS 600D DSLR camera, 5-inch Maksutov-Cassegrain telescope.



ENTER TO WIN A PRIZE!

ALTAIR ASTRO We've teamed up with Altair Astro UK to offer the winner of next month's Hotshots a SkyTech City Light Suppression Filter, designed to block out light pollution while allowing the light from deep-sky objects through. The filter is compatible with all APS-C sized Canon EOS cameras www.altairastro.com • 01263 731505

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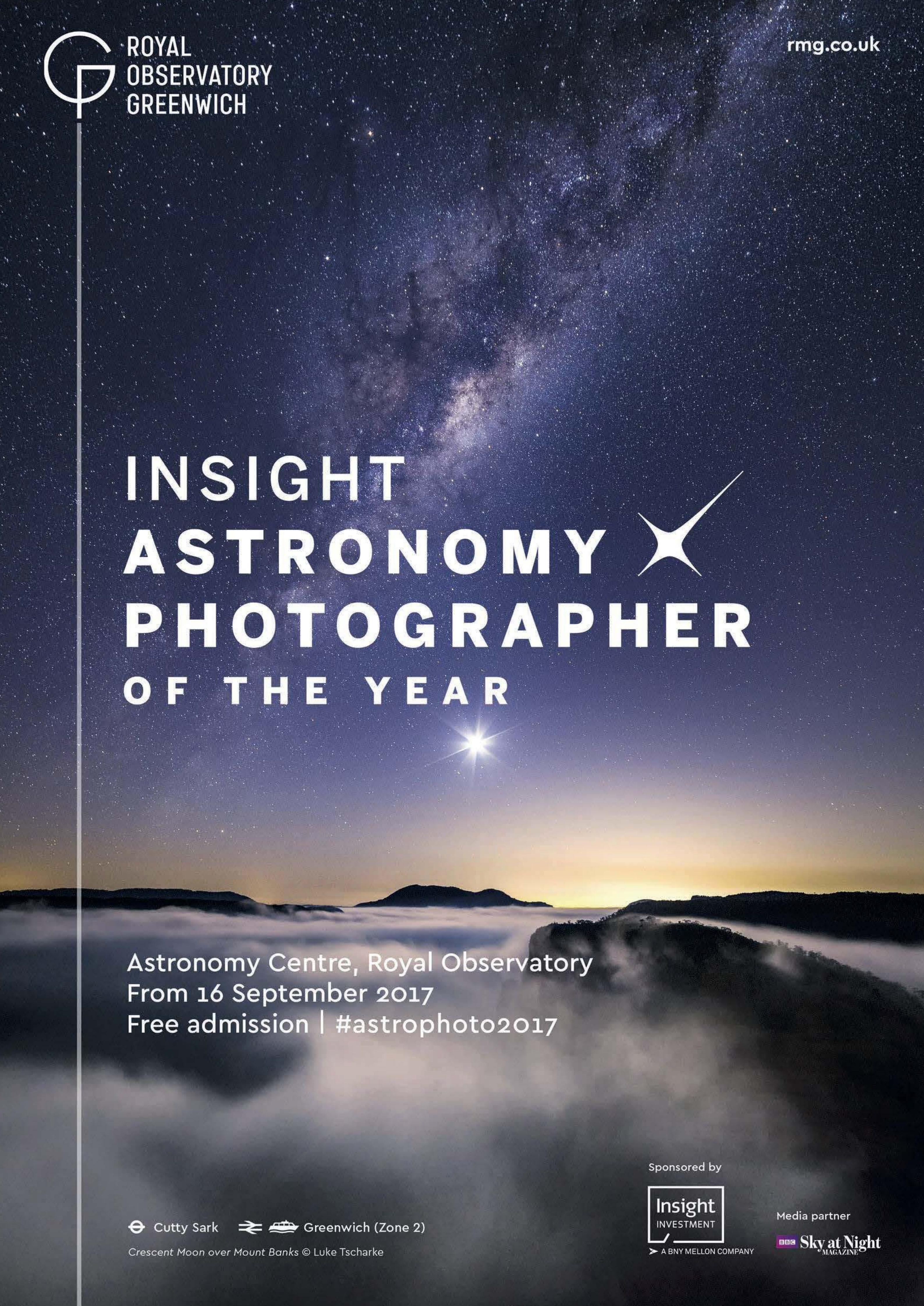

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Crescent Moon over Mount Banks © Luke Tscharke

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BBC Sky at Night
MAGAZINE

Cassini's final descent will begin in a blue Saturnian sky not entirely alien from our own

KEVIN GILL/FLICKR

Diving into the depths

ABOUT THE WRITER
Ben Evans has written nine books on space exploration and is the senior writer for AmericaSpace.

This month, the Cassini probe's epic endeavour at Saturn comes to an end. **Ben Evans** looks back on one of humanity's greatest exploratory missions into space

Speeding towards its doom at 33.5km/s, the final moments of Cassini's 20-year voyage may see the bus-sized spacecraft pass briefly through Saturn's brilliant, cobalt-blue skies, as it concludes one of the most spectacular scientific ventures in history. When Cassini plunges into the ringed planet's yellow-brown atmosphere, the seasonal blue sky will be uncannily reminiscent of Earth's, a small reminder of the world where it was created.

"Saturn's atmosphere starts to turn blue in the winter hemisphere," explains Cassini project scientist Linda Spilker. "The ring shadow and seasonal change are probably responsible for the bluish colour in the ring-shadowed hemisphere," she continues. "The haze particles give Saturn its golden hue glow when sunlight shines on the atmosphere. When shadowed by the rings, or in shadow in the winter, the haze seems to dissipate, allowing scientists to see deeper into the atmosphere. The blue colour is primarily due to the absorption of light by methane."

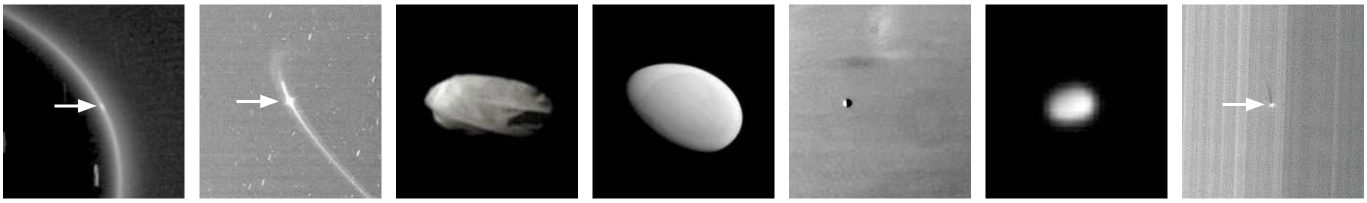
It offers a fittingly wistful reminder of home for a mission conceived over three decades ago by 17 nations, including NASA, ESA and the Italian space agencies. Cassini launched in October 1997 and travelled 3.5 billion km to reach Saturn, picking up gravitational boosts from Venus, Earth and Jupiter along the way. It arrived in July 2004, and released the tiny Huygens lander down to the surface of the giant moon Titan in December of the same year. Cassini went on to perform three extended phases of scientific study: in those past 13 years it has orbited the planet over 290 times, taking in Saturn's equinox and part of its northern summer solstice as it did so.

A mission of discoveries

The mission found seven new moons and explored dozens of others, whose appearance ran the gamut from spherical to potato-shaped ▸

BBC WORLD SERVICE

Prof Lucie Green charts how Cassini has helped us in the search for life elsewhere in *The Documentary: Cassini's Last Adventure*, on the BBC World Service at 1.30pm on 22 August



▲ The seven new moons discovered by Cassini. L-R: Aegaeon, Anthe, Daphnis, Methone, Pallene, Polydeuces and S/2009 S1

▸ and from meatball-like to a kitchen sponge, some planet-sized, others equivalent to the dimensions of a football stadium. More than a hundred flybys of Titan uncovered hydrocarbon rivers, lakes and seas, as well as a potentially habitable subsurface ocean. "Methane plays the role on Titan that water plays on Earth, carving river channels and filling Titan's lakes and seas, while a subsurface ocean resides beneath Titan's icy crust," says Spilker.

Cassini saw water-ice jets spurting from fissures at the south pole of the moon Enceladus, providing a reservoir of material for Saturn's E ring and betraying the existence of a deep global ocean, with all of the ingredients necessary to host some form of life. Still other moons, including the Death Star-like Mimas, with its prominent crater, might also possess oceans, whilst tenuous oxygen atmospheres, trillions of times thinner than our own, were found around Rhea and Dione.

NASA/JPL/SPACE SCIENCE INSTITUTE X 16

As for Saturn itself, the spacecraft witnessed a complex atmosphere on the cusp of seasonal change as the planet progressed along its 29-year orbit. Cassini occupied a ringside seat, observing exotic storms and jet streams, including the 30,000km-wide north polar hexagon, whose winds peak at 320km/h. It photographed violent lightning storms by day and night, mapped the planet's magnetic field and observed the evolution of an annually recurring white storm in the northern hemisphere.

Planning for goodbye

Yet all good things come to an end. Several end-of-mission scenarios were considered, including a prohibitively long trek back to Jupiter, killing Cassini off through an impact with Saturn's rings or moons, or entering a semi-stable graveyard orbit. For the aging spacecraft, none of them promised to be scientifically profitable. And as its fuel dwindled,

TOUCHDOWN ON TITAN

How Huygens reached the most Earth-like moon in our Solar System

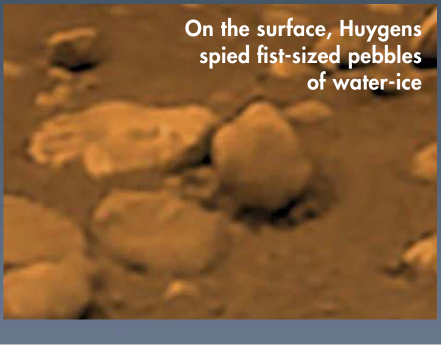
Deep beneath the murky orange clouds of Saturn's large moon Titan lies an Australia-sized plateau called Xanadu. Since 14 January 2005, it has been home to ESA's tiny Huygens probe. Until then, the very nature of Titan's surface – whether liquid or solid – was open to considerable debate. As a result, Huygens was designed to survive a landing on mountainous or flat terrain, and even in a lake or sea.

The spacecraft separated from Cassini on Christmas Day 2004 and coasted for three weeks to its destination. Shortly before entering Titan's atmosphere, a wake-up timer brought its six instruments online. Descending via parachute, it was buffeted by vigorous eastward-blowing winds, which diminished to gentler gusts as it neared the surface to land.

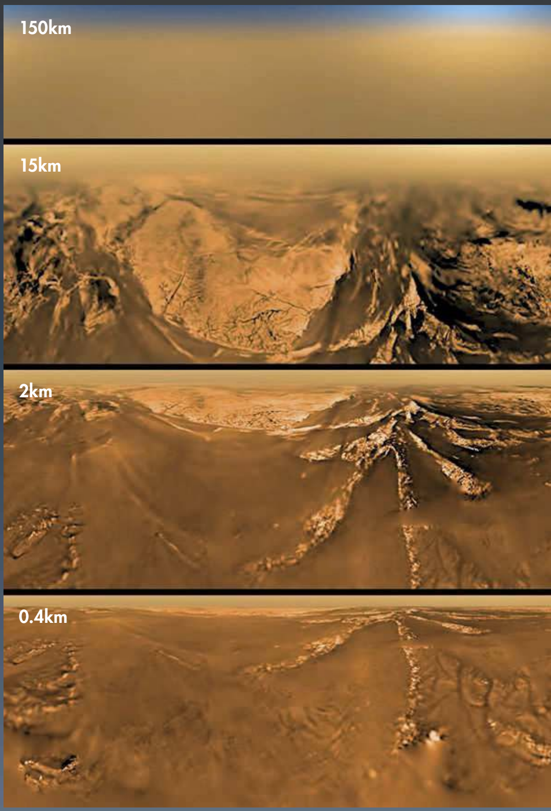
From an altitude of 15km, its images seemed to indicate an area of drainage channels, perhaps leading to a liquid methane 'shoreline', together with tendrils of hydrocarbon ground-fog. However, Huygens landed on solid ground, kicking up a cloud of organic aerosols and leaving a 12cm indent. It bounced, slid, wobbled a few times, then came to a stop.

For 90 minutes, the probe took a look at its gloomy environs, littered with hydrocarbon-coated water-ice pebbles, typically rounded and fist-sized. Early notions of a sticky, clay-like composition were later revised to be a sort of icy 'sand'. Hauntingly, Huygens' on-board microphone provided the first audible sounds from another celestial body, recording the roaring of Titan's wind during descent before its batteries ran dead.

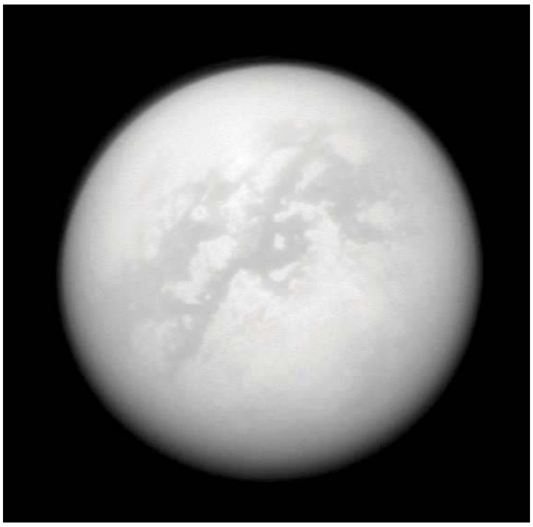
▲ Titan appears as a fuzzy ball due to its thick atmosphere



On the surface, Huygens spied fist-sized pebbles of water-ice



▲ Huygens' view as it descended to Titan, our first glimpse of the surface of this moon

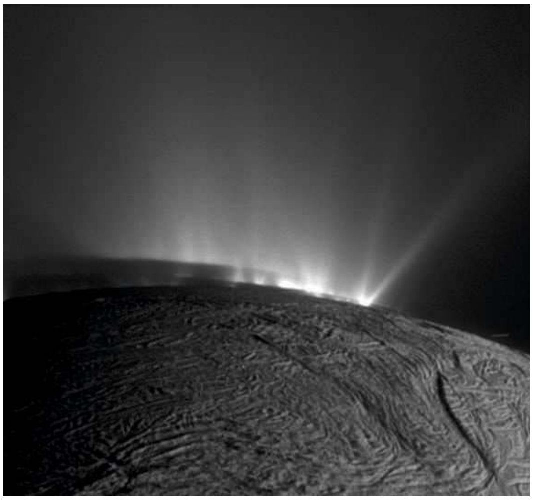


▲ Cassini imaged Titan through its murky atmosphere, revealing what we now know to be lakes of methane

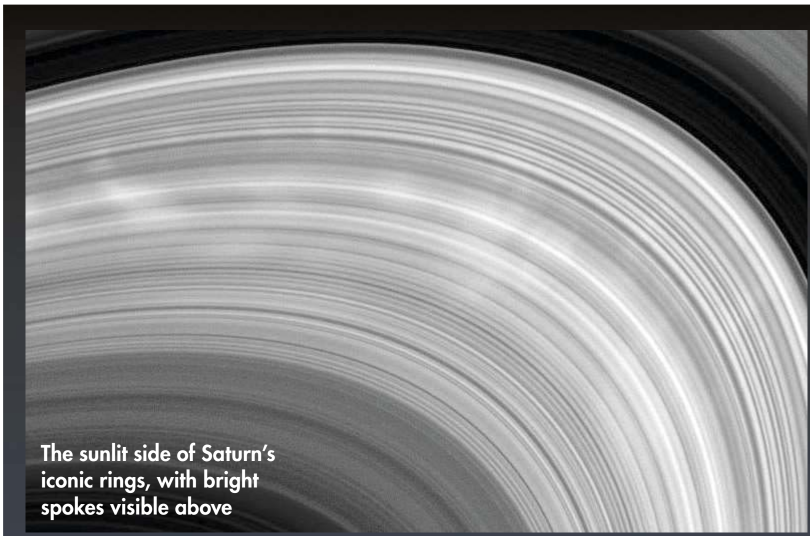
another worry arose. The risk of a long-dead and out-of-control Cassini someday hitting and contaminating pristine Enceladus did not bear thinking about. A safe disposal was imperative.

Saturn's hydrogen-rich atmosphere provided that means of disposal, as well as offering the potential to gain new insights into the formation of the giant planets. Specifically, an enigmatic region of liquid metallic hydrogen, deep inside the gaseous planet, is thought to power Saturn's magnetic field. "Cassini will look for the boundary between the molecular hydrogen layer and the metallic hydrogen layer in the magnetometer data," says Spilker. "Gravity data may reveal whether or not Saturn has a rocky core, one or two Earth diameters in size, and the depth of Saturn's winds."

The result was the Grand Finale: a multi-month campaign that required the spacecraft to execute 22 death-defying 'dives' between the planet and its rings from April to September 2017. On five of those dives, Cassini would actually enter the upper atmosphere, approaching ▸



▲ Cassini not only spotted jets spewing from Saturn's moon Enceladus; it determined they were mainly water



The sunlit side of Saturn's iconic rings, with bright spokes visible above

SATURN'S SPARKLING SPOKES

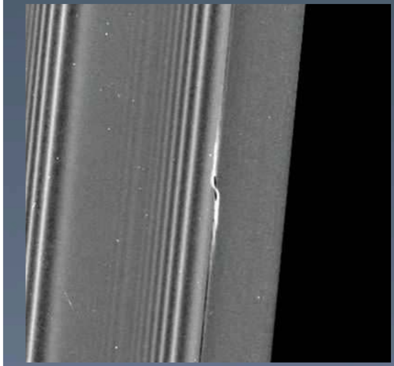
Cassini has taught scientists much about the mysterious features in the planet's rings

Although Pioneer 11 and the two Voyager spacecraft observed Saturn's magnificent assemblage of water-ice rings more than three decades ago, it was not until the arrival of Cassini that their nature was more precisely understood.

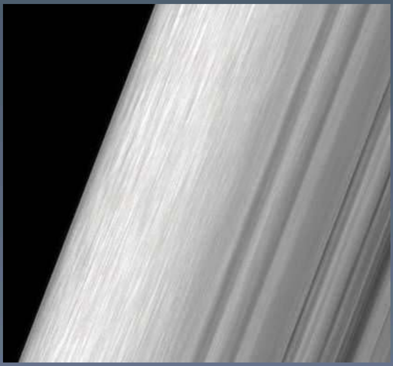
Even as the spacecraft completes its Grand Finale of 22 'dives' between the innermost edge of the rings and the gas giant itself, it is revealing astonishing new details, including features likened to straw and propellers, on scales the size of the Earth's tallest buildings.

The Voyagers observed strange radial 'spokes', up to 16,000km long. The spacecrafts' data on the spokes' formation and dissipation lifecycles implied that they were indeed small particles, suspended high above the plane of the rings by electrostatic charging. Cassini showed these spokes appeared and dissipated in a matter of hours, and its data suggested that they might represent a seasonal phenomenon throughout Saturn's 29-year orbit, vanishing in midwinter and midsummer, and reappearing as the giant planet approaches the equinoxes.

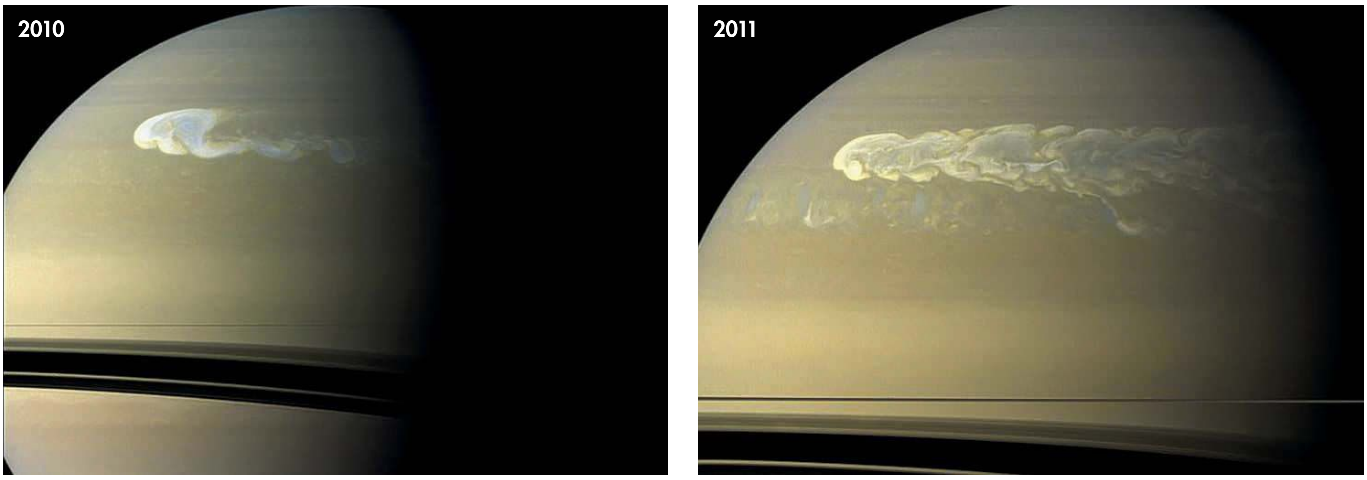
With a breadth of 282,000 km, the rings extend the equivalent of three-quarters of the distance between Earth and the Moon, and their dazzling reflectivity owes itself to the fact that they are composed of 99.9 per cent water-ice, along with contaminants. Cassini's radar and visible observations – together with stellar occultations – have shown varying dimensions of ring particles, which extend from sand-like grains to mountain-sized boulders.



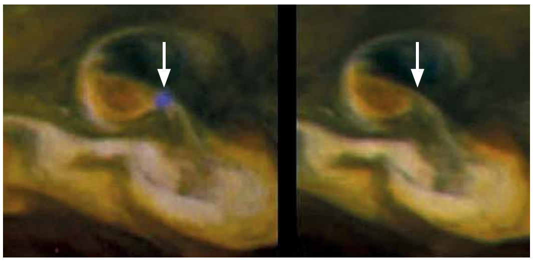
▲ The propeller 'Earheart', a disturbance in the ring caused by a central moonlet



▲ Straw structure due to clumping, observed on the edge of Saturn's B ring

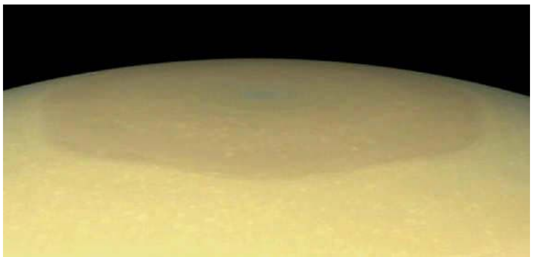


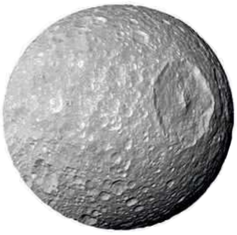
▲ Cassini witnessed a churning white storm in Saturn's northern hemisphere, which appeared to grow and leave a tail in its wake



◄ Lightning was seen on Saturn (left) and the same spot after the flash had dissipated (right)

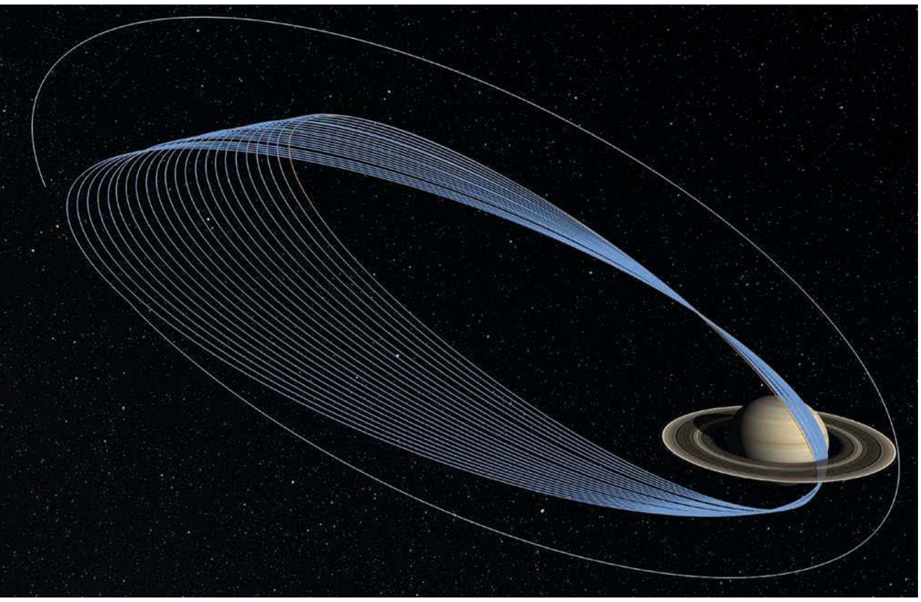
► Saturn's north polar hexagon, a jetstream that evolves with the seasons





▲ Saturn's Death Star-like moon Mimas, dominated by crater Herschel

▼ Cassini has made 22 dives between Saturn and its rings; the orange track is the final loop before its final descent



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▸ within 1,700 km of Saturn's one-bar level, roughly equivalent to sea level pressure here on Earth. "This planned conclusion for Cassini's journey was far and away the preferred choice for the mission's scientists," says Spilker. "Cassini will make some of its most extraordinary observations at the end of its long life."

Early in 2016, the spacecraft completed five manoeuvres to drastically reshape its orbit from an equatorial one into a higher inclination. Last November, a series of 20 'ring-grazing' orbits commenced, during which Cassini hurtled within a thousand kilometres of the F ring – the outermost boundary of Saturn's dazzling necklace – every week for almost five months. At this distance, it could directly sample particles from the rings for the first time and resolved features as large as the tallest buildings on Earth.

The final countdown

The ring grazing phase ended on 22 April, when Cassini gained a gravitational tweak from Titan to establish the proper conditions for the Grand Finale. Four days later, moving at 34.4km/s, it made its initial dive through a gap between Saturn's cloud-tops and the inner edge of the innermost D ring. This positioned Cassini closer to the planet and its rings than ever before.

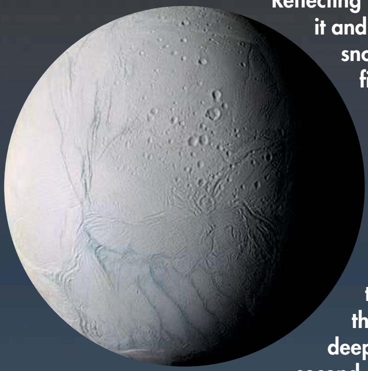
As a precautionary measure, its high-gain antenna was used to shield the delicate scientific instruments against particle impacts, but the region proved surprisingly dust-free. It was even nicknamed "the big empty" by Cassini project manager Earl Maize. Over the following weeks, the spacecraft dived through the rings every 6.5 days, imaging their entire radial extent at breathtaking resolution, measuring Saturn's gravitational and magnetic fields and extensively mapping its northern and southern hemispheres.

Rhythmically looping out to 1.3 million km from the planet, then sweeping inbound for another dive, the spacecraft's last five orbits from mid-August 2017 promised great drama, great risk and even greater reward. At this stage, Cassini was so close to Saturn that it would physically pass through its tenuous upper atmosphere, sampling various species of molecular hydrogen and helium, examining small-scale structures and observing its powerful polar aurorae and fast-moving vortices.

As it completes its 292nd and final full orbit on 12 September, Cassini will perform a distant flyby of Titan. The moon's gravity will offer a 'goodbye kiss',

AS ABOVE, SO BELOW?

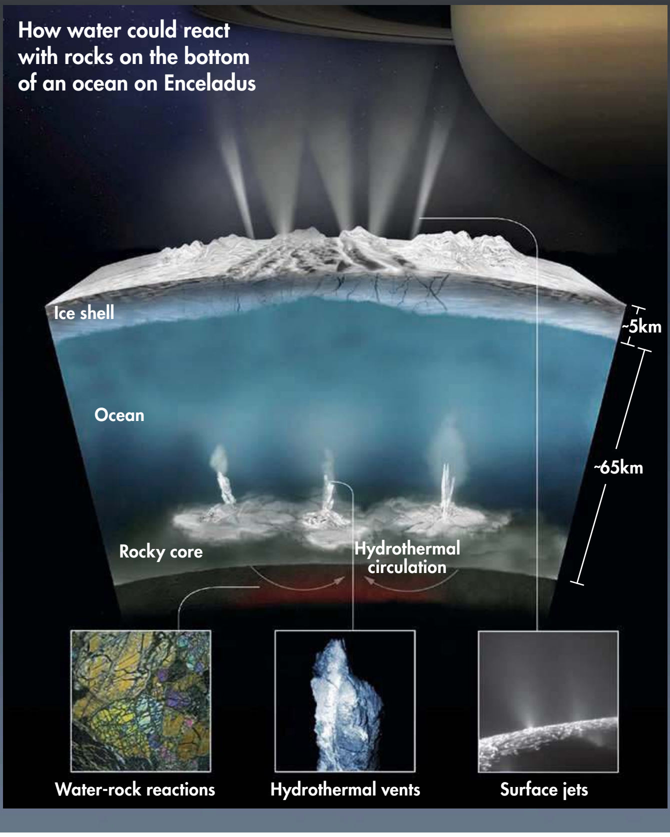
Observations of Enceladus have revealed much about what lies below the moon's icy crust



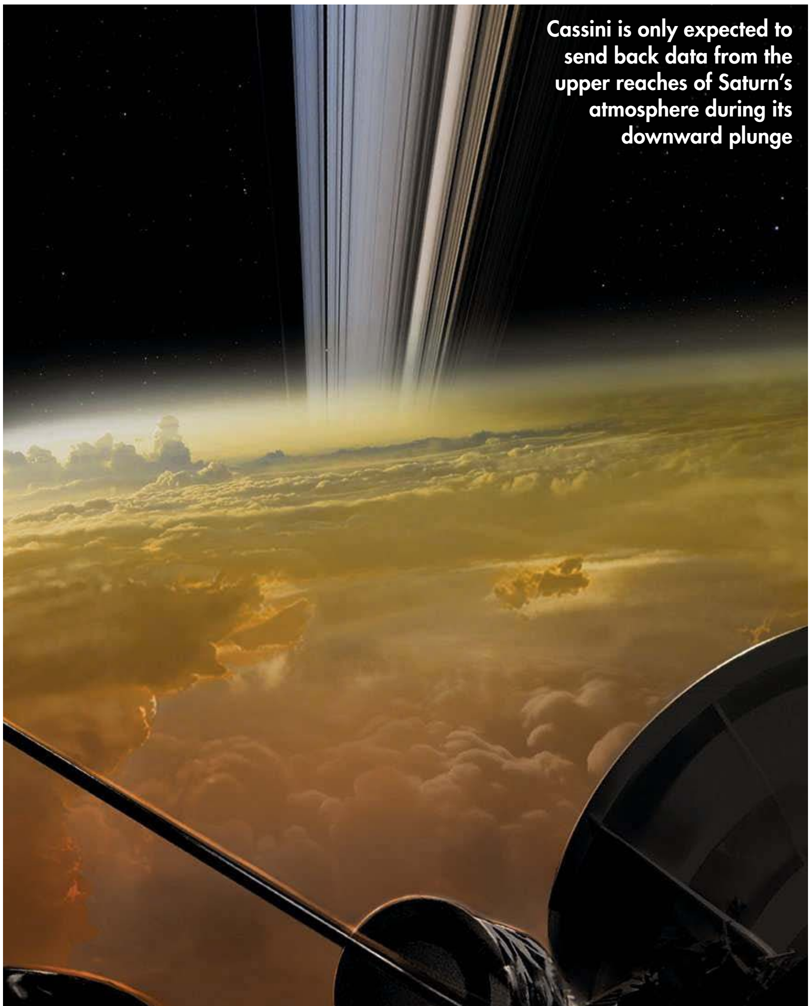
Reflecting 95 per cent of the sunlight that strikes it and brighter than a field of freshly fallen snow, Enceladus's youthful façade was first observed by the twin Voyager spacecraft, which raised the possibilities of 'cryovolcanism' and perhaps the existence of a life-sustaining ocean beneath its frozen crust. A quarter of a century later, in 2005, Cassini turned its gaze to Enceladus and validated long-held theories that water-ice geysers in the polar region – gushing from deep fissures at hundreds of metres per second – were responsible for supplying many microscopic particles to Saturn's E ring.

Later that year, Cassini passed directly through one of the plumes, revealing the presence not only of water vapour, but also volatiles such as nitrogen, methane and carbon dioxide. This enhanced the possibility that some form of hydrothermal activity could be at work deep within Enceladus and strengthened theories that the tiny moon could harbour a salty subsurface ocean ripe for nurturing microbial life. Plumes of salty particles from so-called 'tiger-stripe' fissures at the south pole and gravitational field data from Cassini strongly inferred the existence of a salty ocean, perhaps up to 10km deep.

"Cassini's revolutionary findings at tiny Enceladus include a subsurface global, salty ocean containing organics, ammonia, hydrogen and silicates, with hydrothermal vents on its seafloor," says Spilker. "These discoveries have fundamentally altered many of our concepts of where life may be found in our Solar System."



How water could react with rocks on the bottom of an ocean on Enceladus



Cassini is only expected to send back data from the upper reaches of Saturn's atmosphere during its downward plunge

adjusting the spacecraft's course and causing it to plunge deep into Saturn's atmosphere. The final, partial orbit will end at 10:44 UT on 15 September, and Cassini will begin its descent just south of the equator, in the dead of the Saturnian winter.

With thrusters pulsing as it struggles to keep its high-gain antenna locked on Earth, Cassini will continue to gather new data, transmitting until the very end. Its demise will be swift. "Cassini's tiny thrusters will not be able to keep the spacecraft pointed at Earth very deep into the atmosphere," explains Spilker. "The flight team is not sure when the spacecraft will begin to tumble, but it will happen quickly. Cassini will only send back data on the uppermost portion of Saturn's atmosphere."

Back on Earth, we will know nothing of the speccraft's end for over an hour. Travelling at the speed of light, across the 1.2 billion km gulf between Saturn and Earth, its final data will reach the electronic ears of NASA's Deep Space Network at 12:07 UT. Confirmation of the final loss of signal is anticipated only a minute or so later; a bittersweet end to one of our longest space missions. Yet as Cassini vanishes from existence and becomes part of the planet it has spent its life exploring, we can modify a line from the famous poet Rupert Brooke, and be certain that some tiny corner of a foreign gas giant will remain forever Earth. S

Heading into the wilderness can give you a fresh perspective on the skies and new options for composing your astrophotos

La Palma, the Australian Outback, the Namibian Desert, the icy Arctic; for many of us just hearing names like those conjures up visions of pristine dark skies and awe-inspiring phenomena all mixed with an intoxicating sense of wanderlust. They are the destinations of our dreams, of our bucket lists. But these beautiful locations, and the thrill of exploring them, needn't be the only subjects for such wistful imaginings.

While the UK might not have the night skies to rival Down Under or the climate of the Canary Islands, there are still adventures to be had closer to home. Journeys where breathtaking astronomical sights or transient events can be seen and chased, alongside the excitement of exploring a new place or a beautiful landscape. We like to think of it as 'wild' astronomy.

A 'wild' astronomy adventure, then, could be as simple as an evening drive to a rural spot to observe or image – for a few hours – away from urban lights, under darker skies than those you have at home. Many observers and astrophotographers do this on a regular basis as part of their local astronomical society's activities or on nights when there's a decent meteor shower peaking or a display of aurora anticipated.

Although it may sound like overkill, if you've never observed or imaged from a remote location before, planning your

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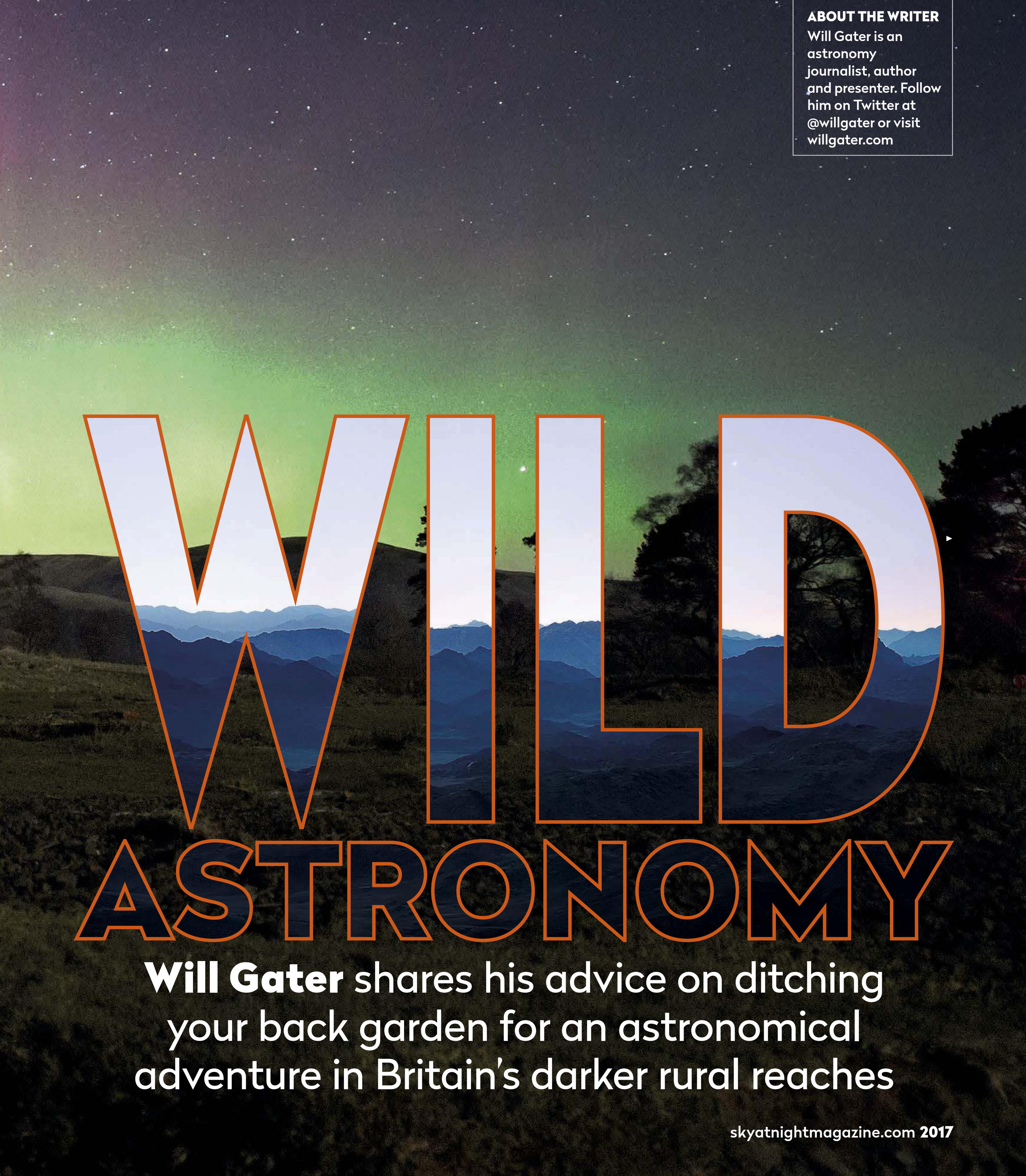
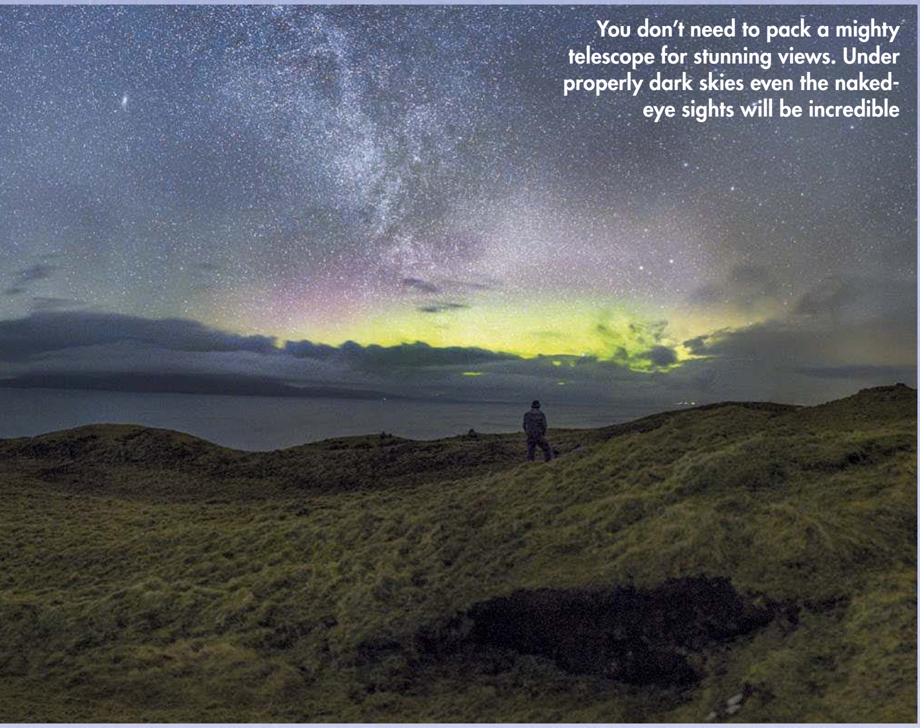
ABOUT THE WRITER
Will Gater is an astronomy journalist, author and presenter. Follow him on Twitter at @willgater or visit willgater.com

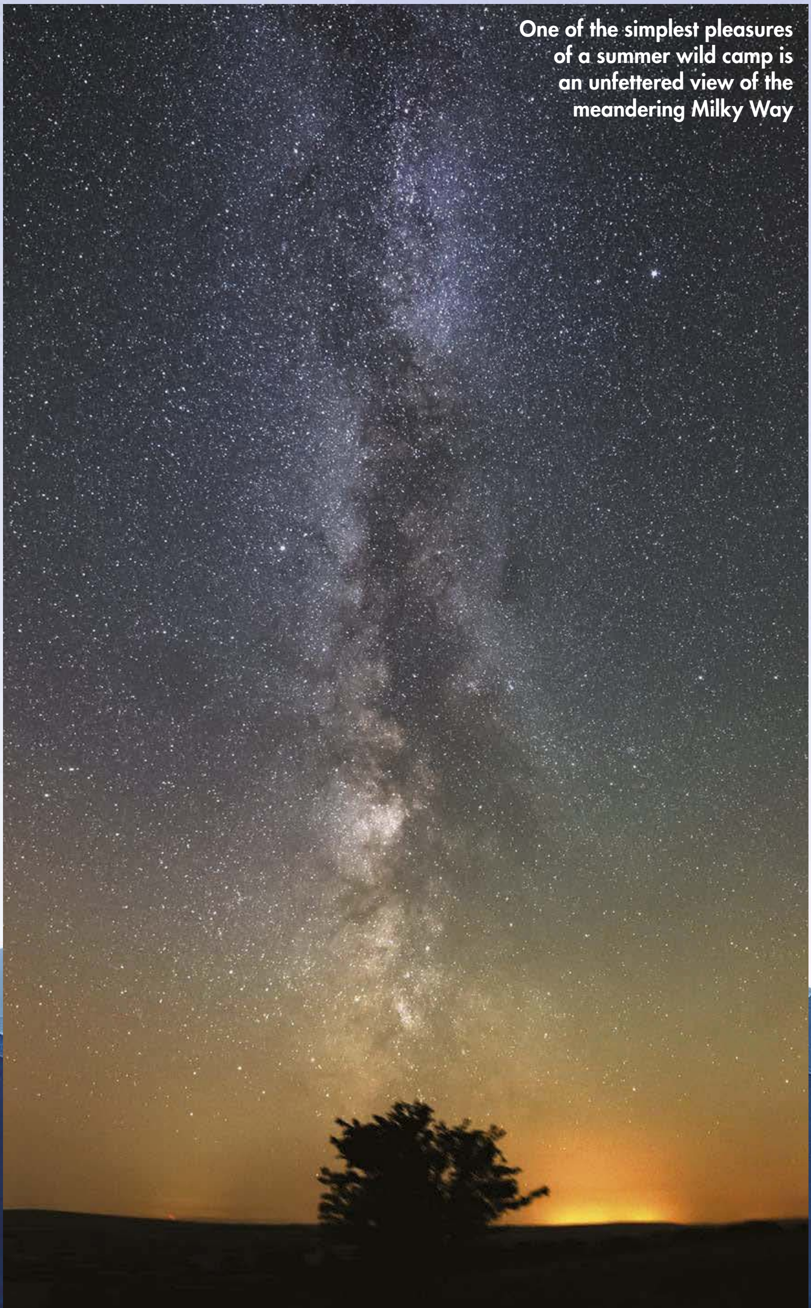


WILD ASTRONOMY

Will Gater shares his advice on ditching your back garden for an astronomical adventure in Britain's darker rural reaches



You don't need to pack a mighty telescope for stunning views. Under properly dark skies even the naked-eye sights will be incredible



One of the simplest pleasures of a summer wild camp is an unfettered view of the meandering Milky Way

▸ trip carefully – however long it may be– will make things go much more smoothly and help mitigate some of the risks you may encounter along the way.

There are many practical aspects to think about when planning a wild astronomy trip, but there are other considerations too. It's not just about remembering to bring the power cable for the mount, or making sure your DSLR's spare battery is charged. It's also about your personal safety and comfort while in the field.

Playing it safe

It's always good practice to let a family member or friend know exactly where you're going, along with a map grid reference of your observing site and when you expect to return. If you can, take someone with you on your trip; not only will you have someone to share the fun of the adventure with, but they may also be a useful pair of hands if you run into difficulties. Local knowledge can be invaluable too. Local societies and astronomers may be willing to point you in the direction of their favourite observing sites, as well as offer advice on places to avoid.

A great deal of amateur astronomy in the UK happens in the winter months and going on remote observing or imaging trips at this time of year requires a cautious approach and additional preparations. Road conditions during the winter can be treacherous and some smaller, rural roads that lead to good sites for observing and astrophotography – such as high-altitude terrain or remote moorland hills – might not necessarily be treated for any potentially icy conditions, like many main roads are. Here you should always follow the advice of the police and local authorities. If the road conditions look hazardous, don't put yourself in danger – there's no observation or astrophoto that's worth the risk.

> **“Changeable and harsh weather is itself something to be prepared for”**

Changeable and harsh weather is itself something to be prepared for. You'll obviously want to take warm, waterproof, clothing on your trip to wear while you're observing or imaging, but it's also

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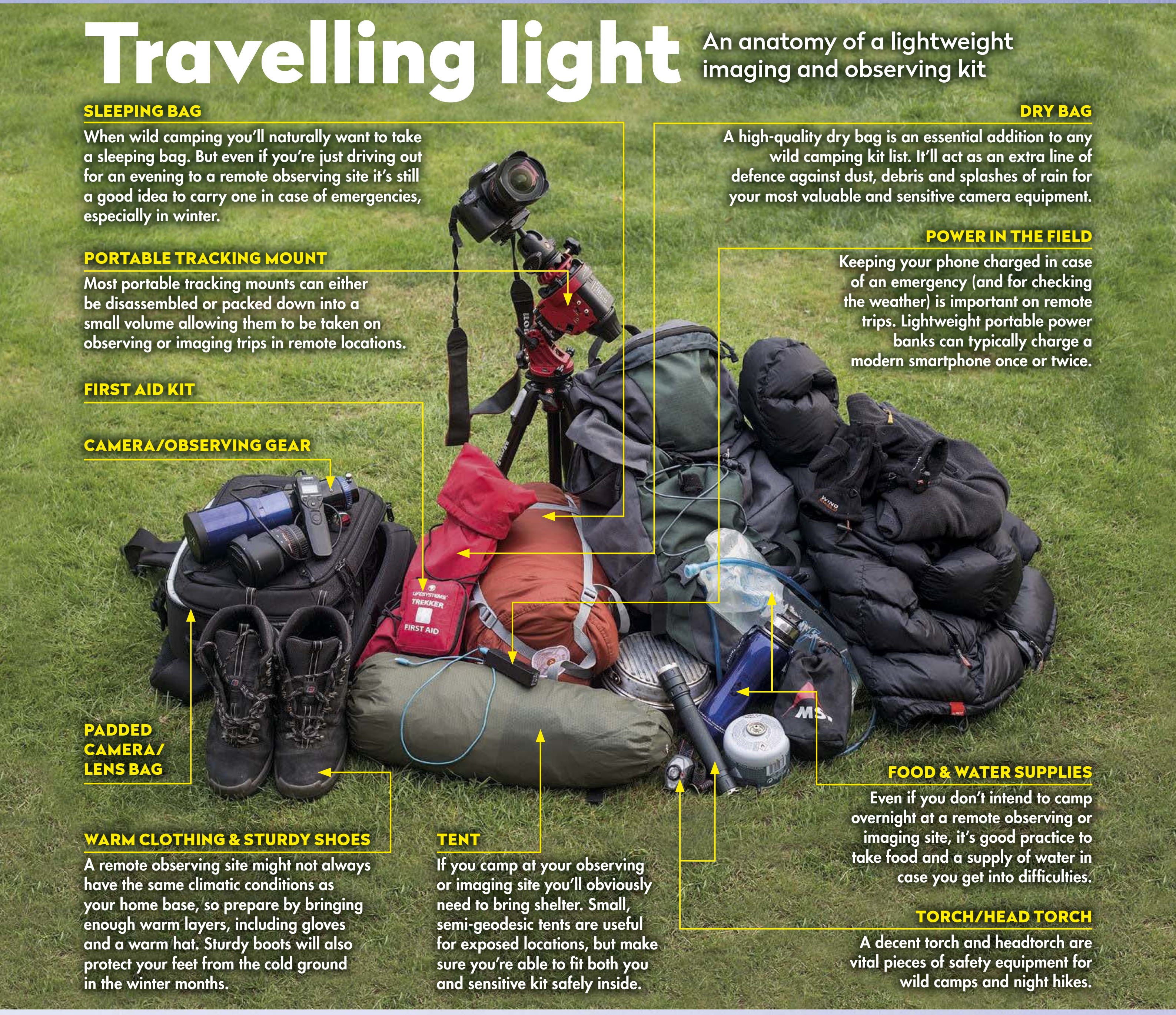
Travelling light

An anatomy of a lightweight imaging and observing kit



SLEEPING BAG
When wild camping you'll naturally want to take a sleeping bag. But even if you're just driving out for an evening to a remote observing site it's still a good idea to carry one in case of emergencies, especially in winter.

PORTABLE TRACKING MOUNT
Most portable tracking mounts can either be disassembled or packed down into a small volume allowing them to be taken on observing or imaging trips in remote locations.

FIRST AID KIT

CAMERA/OBSERVING GEAR

PADDED CAMERA/ LENS BAG

WARM CLOTHING & STURDY SHOES
A remote observing site might not always have the same climatic conditions as your home base, so prepare by bringing enough warm layers, including gloves and a warm hat. Sturdy boots will also protect your feet from the cold ground in the winter months.

TENT
If you camp at your observing or imaging site you'll obviously need to bring shelter. Small, semi-geodesic tents are useful for exposed locations, but make sure you're able to fit both you and sensitive kit safely inside.

DRY BAG
A high-quality dry bag is an essential addition to any wild camping kit list. It'll act as an extra line of defence against dust, debris and splashes of rain for your most valuable and sensitive camera equipment.

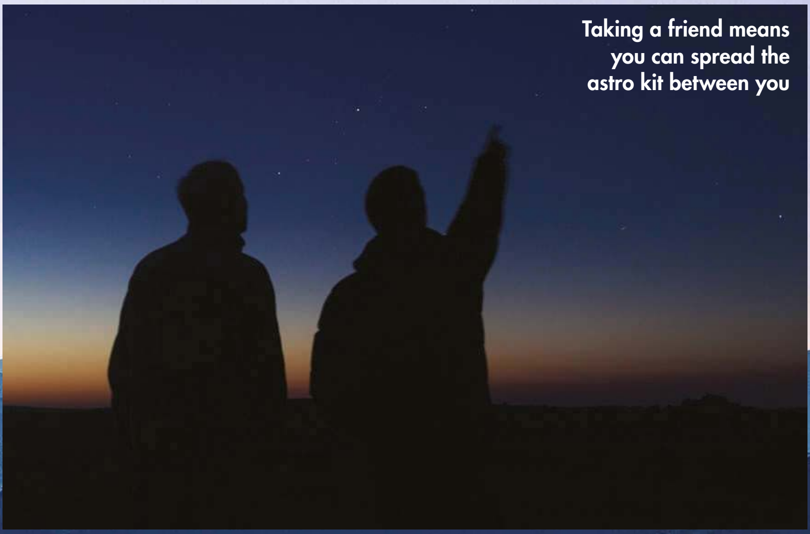
POWER IN THE FIELD
Keeping your phone charged in case of an emergency (and for checking the weather) is important on remote trips. Lightweight portable power banks can typically charge a modern smartphone once or twice.

FOOD & WATER SUPPLIES
Even if you don't intend to camp overnight at a remote observing or imaging site, it's good practice to take food and a supply of water in case you get into difficulties.

TORCH/HEAD TORCH
A decent torch and headtorch are vital pieces of safety equipment for wild camps and night hikes.

worth throwing in a sleeping bag (or even better, a bivvy bag) for emergencies. Be sure to have a good supply of food and water with you too.

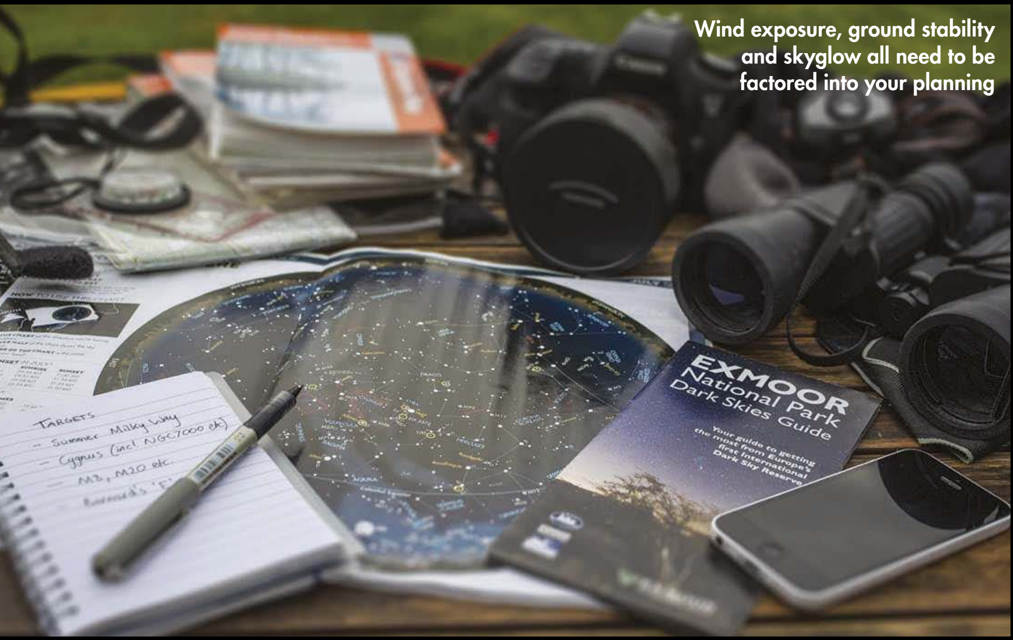
Not all wild astronomy adventures will be evening drives to remote locations of course. Night hikes or even multi-day wild camps, out in the countryside rather than at a campsite, are a wonderful way to get out and see the stars from some of the UK's few remaining truly dark-sky sites. What's ▸



Taking a friend means you can spread the astro kit between you

Planning a remote observing trip

Practical considerations to get the best observing experience while out in the wilderness


EXMOOR National Park Dark Skies Guide
Your guide to getting the most from Europe's first International Dark Sky Reserve
TARGETS
– Summer Milky Way
– Cygnus (incl NGC7000 etc)
– M8, M20 etc
– Barnard's

Wind exposure, ground stability and skyglow all need to be factored into your planning

One of the keys to a successful remote observing or imaging trip is extensive planning. Careful preparation is important for safety reasons, but it's also invaluable in terms of the more practical requirements of stargazing and astrophotography. Is the location exposed to the wind? Is there stable ground for your telescope? Is it safe and legal to get to? Will the landscape block your view? All of these things, and more, will need to be considered before your trip.

Your choice of destination will likely vary on a number of factors: how much time you have for travelling, whether you intend to camp or visit briefly, the time of year and the object or phenomenon you want to catch. If you're thinking of visiting one of the more famous dark-sky locations in the UK – Exmoor, Kielder Forest, Galloway Forest Park, or similar – most of the organisations that look after these landscapes have published leaflets which recommend observing sites.

For visits elsewhere light pollution maps are great for a general overview, but they're not necessarily indicative of actual skyglow, the light pollution domes or individual light sources you'll experience at a given location – especially when it comes to astrophotography. A site that looks 'dark' on a map could still suffer from any of these. If you can find 'nightscape' astrophotos online taken from or near your planned observing site, these can sometimes give a rough indication of the presence and position of any light domes.

We recommend visiting your chosen site in daylight beforehand if you're able to. This will allow you to have a detailed look around the area and find interesting angles for astrophotos. Try to go at the same time of year as when you intend to visit, not least because changing greenery may dramatically affect your compositional choices and obstruct lower parts of the sky.

Sometimes a daylight reconnoitre beforehand just isn't possible. Instead, you can get a rudimentary impression of a location – and see where celestial targets will be in relation to the surrounding topography – using an Ordnance Survey Explorer map, online tools such as Google Street View and smartphone apps such as The Photographer's Ephemeris.

▸ more, many of these dark sky areas are places where there are spectacular landscapes and picturesque towns and villages to explore during the daytime.

The kit conundrum

One of the major challenges surrounding astrophotography or visual observing as part of a hiking or remote camping trip is keeping the weight of your astronomical kit down as much as possible. Some small refractors are portable enough to be taken on night hikes and wild camps, but – just like DSLRs and the fast, wide-angle lenses that are usually the go-to choice for remote imaging trips – they'll need to be very carefully protected from dirt, the elements and accidental knocks. For comfortable observing, small refractors also tend to require a very solid tripod, but sturdy tripods are usually heavy and cumbersome to carry on long walks. Alternatively, simply enjoy the naked-eye view of the skies on these sorts of trips – which, alongside the occasional meteor, can often be entertainment just in itself – and if

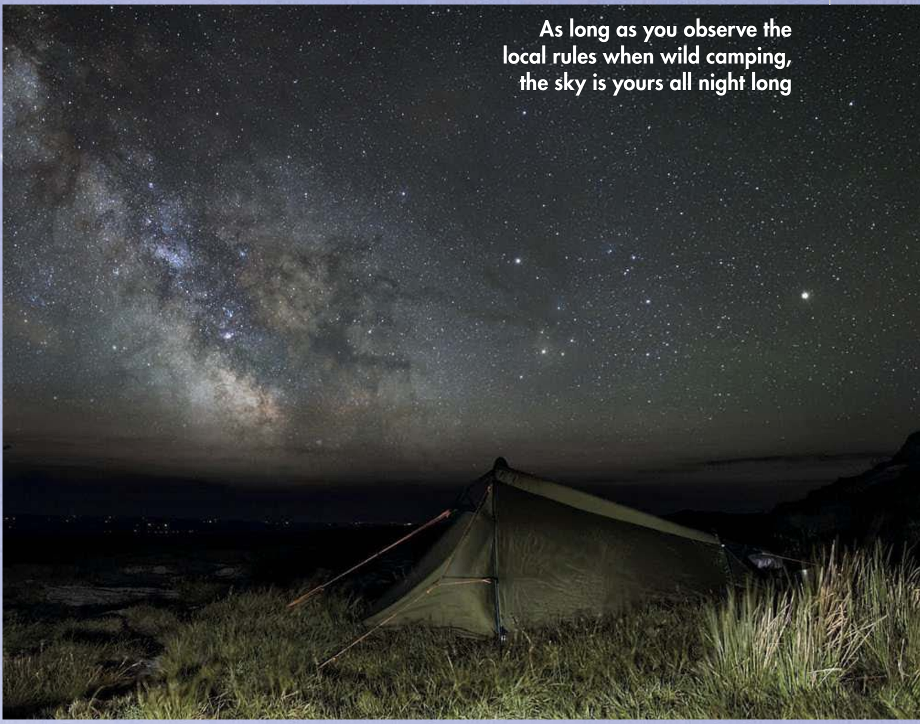
▼ You don't even need to camp. With the right precautions, you can hike under the stars

WILL GATER X 4, STUART MCINTYRE, ISTOCK

you want to explore the sky a little deeper, take a pair of binoculars with you; they'll be perfectly adequate for observing the larger and brighter star clusters and nebulae.

Wild camping (ie, camping outside an official campsite) is allowed on certain parts of Dartmoor and in some areas of Scotland, but be sure to familiarise yourself with the by-laws and wild camping guidelines (or restrictions) at these locations before you set out. Certain parts of Dartmoor, for example, are used as live-firing ranges by the British Army. For anywhere else in the UK you'll need to follow the local rules and by-laws regarding camping and if necessary get permission from the landowner or relevant authority before you embark on your trip .

Wild camping naturally requires more kit than a quick evening trip, such as a tent, a decent sleeping bag, cooking equipment and walking boots, but just as with short excursions always tell someone where you are going and take enough water and food supplies with you. A properly-stocked first aid kit is a must and insect repellent is advisable too in the summer months. All the effort of hiking to an isolated observing spot is worth it though. If you ask us, there are few greater pleasures in life than lying back while on a wild camp and scanning the summer Milky Way with binoculars. So, the only question remaining is, where will your first wild astronomy destination be? Ⓢ


As long as you observe the local rules when wild camping, the sky is yours all night long

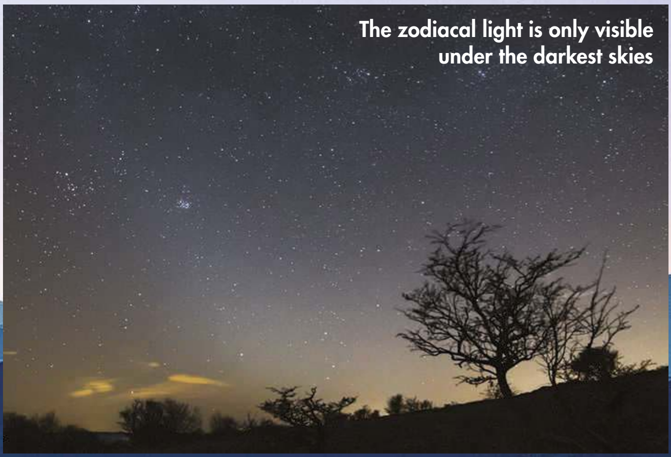
> **"Wild camping is allowed in parts of Dartmoor and in some areas of Scotland, but familiarise yourself with relevant by-laws"**

Wonders of wild astronomy

Why should you even consider leaving the comfort of your regular observing site at all?

Wild astronomy isn't just about the thrill of an adventure and the pleasure of stargazing or imaging in beautiful locations. It's also about going in search of things that we can't ordinarily be seen from a light-polluted home location. Even just an evening's drive from the skyglow of suburbia can reveal more stars and is likely to give you better views of deep-sky objects you may struggle to see with your scope at home. For events like major meteor showers it's great to get out to a dark-sky site, as the darker skies will allow you to see fainter meteors, really enhancing the excitement of the 'shower' experience. Similarly, phenomena such as the faint zodiacal light or the rich star fields of the summer Milky Way make wonderful celestial targets to build a night hike or wild camp around. You can even use such trips to push the boundaries of your observing experience. For example, we've enjoyed marvellous naked-eye views of the elliptical 'smudge' of light that is the Andromeda Galaxy (M31) on wild camps on Dartmoor and even caught naked-eye glimpses of the Triangulum Galaxy (M33) on nights with excellent sky conditions.

The faint smudge of M33 and the constellation of Cepheus


The zodiacal light is only visible under the darkest skies

Buzz Aldrin
Why we've got to get to MARS

He may be one of the most famous moonwalkers, but Buzz Aldrin has spent the past 30 years developing a plan to get people to Mars. He tells **Jamie Carter** why

> **"What concerns me most about expeditionary missions is that we may go there once or twice and never go back. It would be flags and footprints again"**
> **Buzz Aldrin**

Colonising the Solar System is becoming the 'in' thing among billionaires. SpaceX supremo Elon Musk recently talked putting a million people on the Red Planet within 100 years, while Blue Origin's Jeff Bezos thinks he can help spread a trillion people throughout the Solar System. That's big talk, but there's one man who's spent the last three decades telling anyone who'll listen about his plans to go to Mars, and why it's so important we do so.

"I'm 87 years old and I'm getting impatient," says Dr Buzz Aldrin, who walked on the Moon in 1969 as part of Apollo 11. "We've been stuck in low-Earth orbit for too long and I believe that we need to break this malaise," he says. "I do believe we can establish permanent habitation on Mars by 2039, and I have a plan to achieve it."

If that date seems rather specific, there's a good reason for it: it would be the 70th anniversary of Apollo 11's Moon landing. Not that Aldrin wants to be constantly reminded of that. It may be regarded as a seminal moment for humanity, but only until someone sets foot on Mars.

"I want to be remembered as the man who led the world to Mars, for a permanent settlement," he points out.

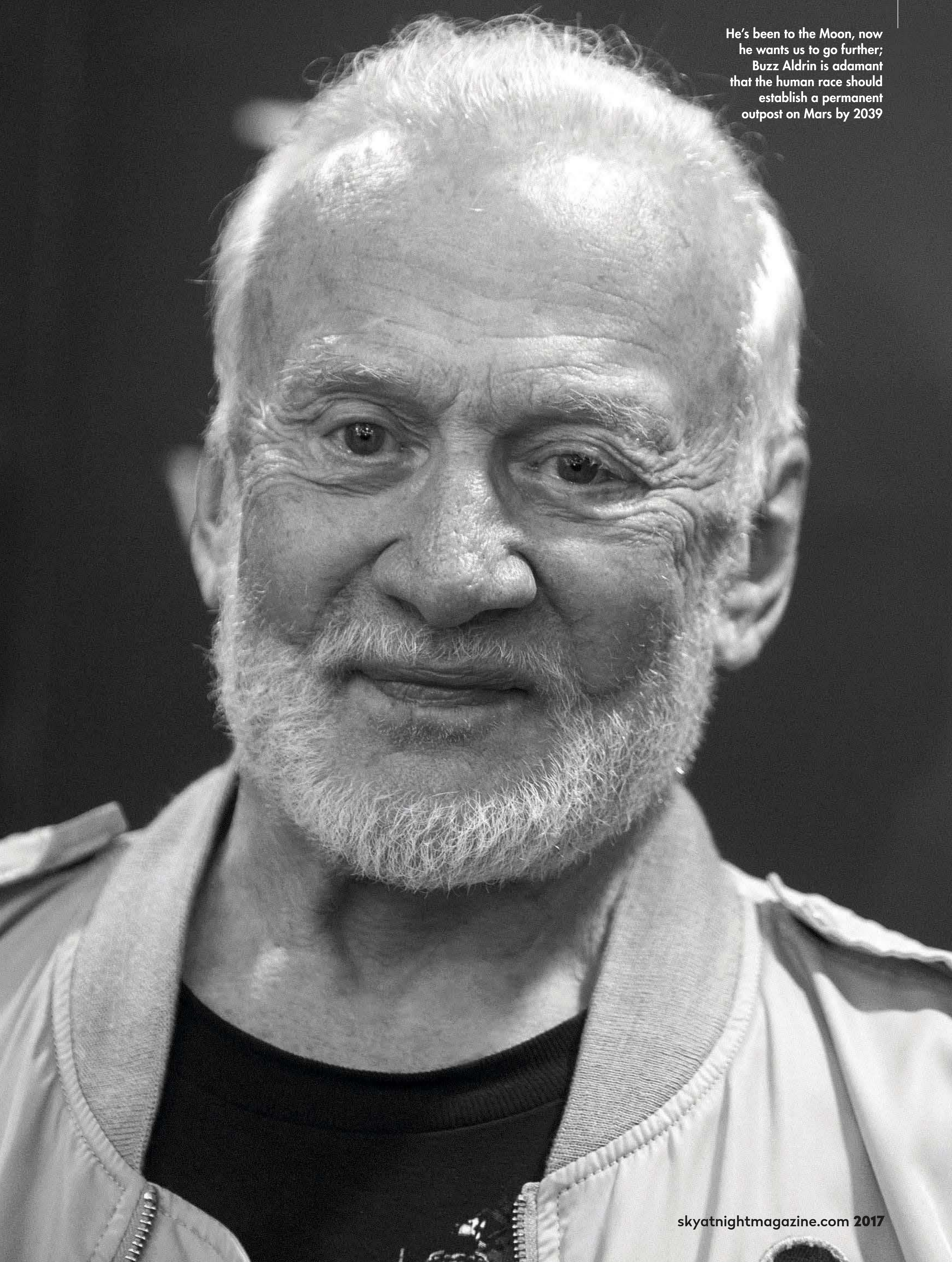
▲ Aldrin seen spacewalking during the Gemini 12 mission

Occupation vs exploration

Aldrin, who is constantly refining the ideas he first set out in his 2013 book *Mission to Mars: My Vision for Space Exploration*, now wants to play a pivotal role in the push to the Red Planet. But there remains a fundamental question: why do we need to occupy Mars? Why not just pay it a quick visit?

"What concerns me most about expeditionary missions is that we may go there once or twice and never go back – it would be flags and footprints again," says Aldrin, citing the Apollo Moon landings, the last of which was 45 years ago. "But the more important reason is that it's vastly more expensive to send people up there with all their infrastructure in one spacecraft and the quality of the science would be dramatically lower." ▸

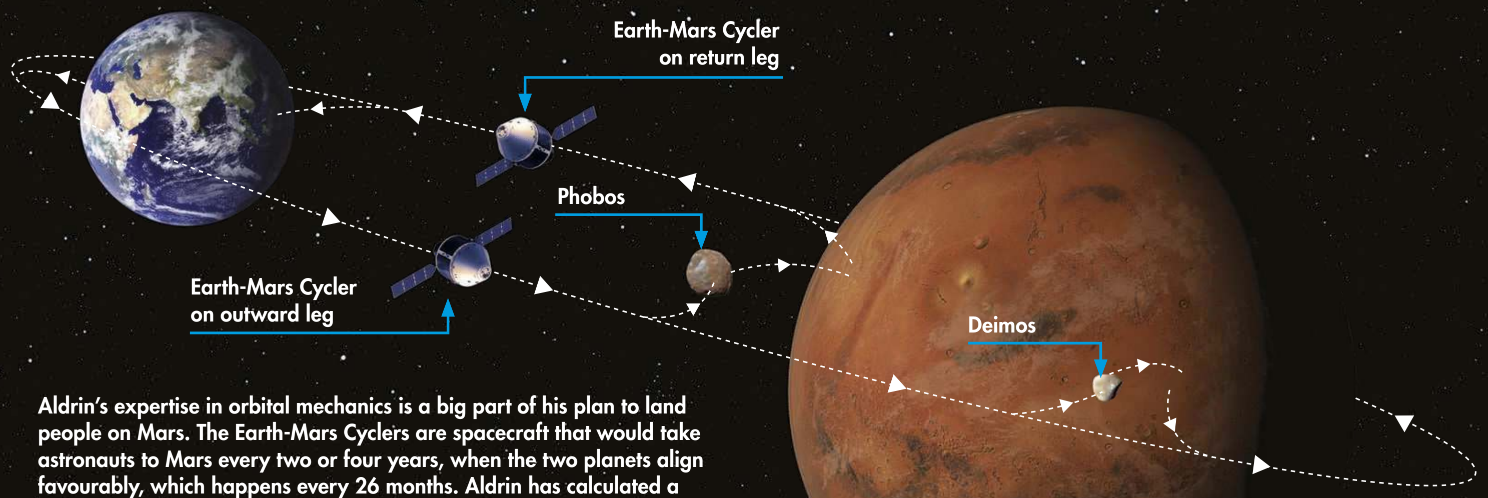
ISTOCK, NASA, NASA-JPL-CALTECH, MARK THOMAS/REX/SHUTTERSTOCK



He's been to the Moon, now he wants us to go further; Buzz Aldrin is adamant that the human race should establish a permanent outpost on Mars by 2039

THE EARTH-MARS CYCLER

How Aldrin's interplanetary ferry might work



Aldrin's expertise in orbital mechanics is a big part of his plan to land people on Mars. The Earth-Mars Cyclers are spacecraft that would take astronauts to Mars every two or four years, when the two planets align favourably, which happens every 26 months. Aldrin has calculated a trajectory that makes the journey in only three months, rather than the usually quoted 150–300 days.

"The technology is not any sort of magical propulsion, it is just an orbital trajectory I began developing over 30 years ago," says Aldrin. "The easiest way to think about it is that it's like an orbit around Earth except that it is orbiting between Earth and Mars."

There's another unique characteristic to Aldrin's plan: astronauts would use the Martian moons Phobos and Deimos as stepping stones to the surface.

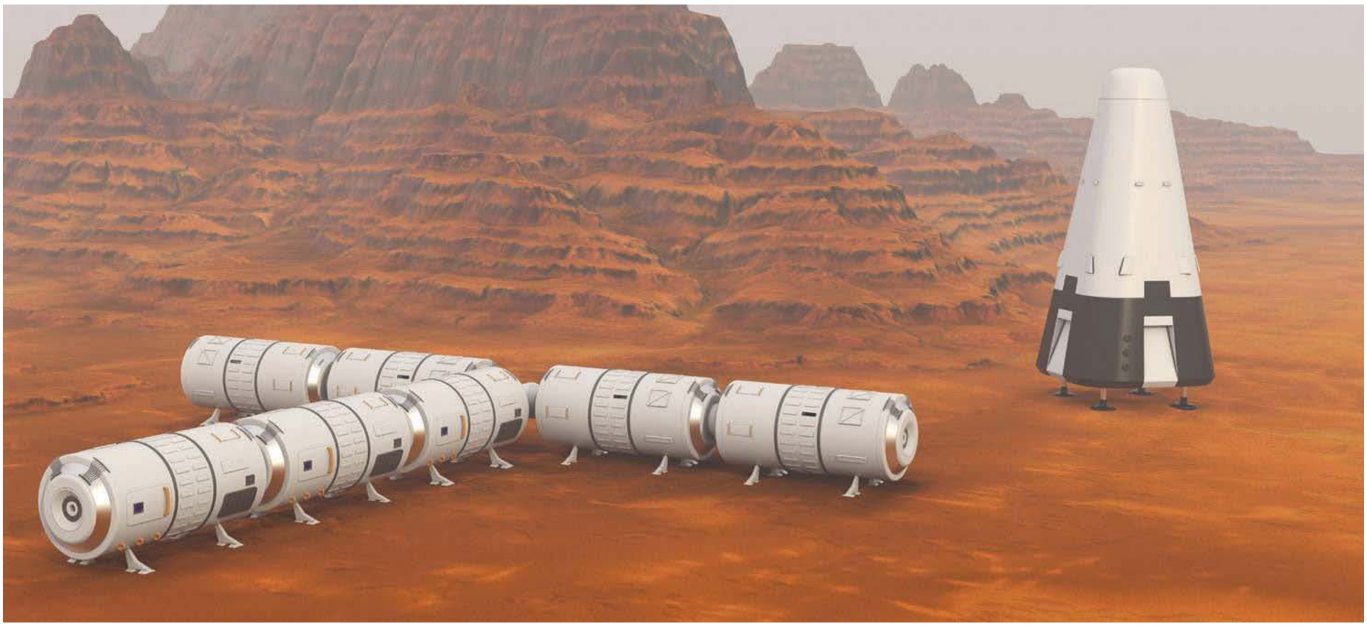
▸ According to Aldrin, once you have the right kind of surface and transportation infrastructure, the cost of sending individual astronauts would be affordable. His is a pragmatic plan built upon orbital calculations that could make inhabiting Mars far more affordable than anyone imagines.

Aldrin's idea revolves around the concept of 'Cycling Pathways': one or possibly two Earth-Mars spacecraft (a 'Cycler') that travel constantly between Earth and Mars. "The astronauts will be transported to the Earth-Mars Cycler with a single launch, with refuelling in Earth orbit," explains Aldrin. "Using spacecraft that cycle between Earth and Mars would be an order of magnitude cheaper than using an entirely new series of rockets to send each crew to Mars."

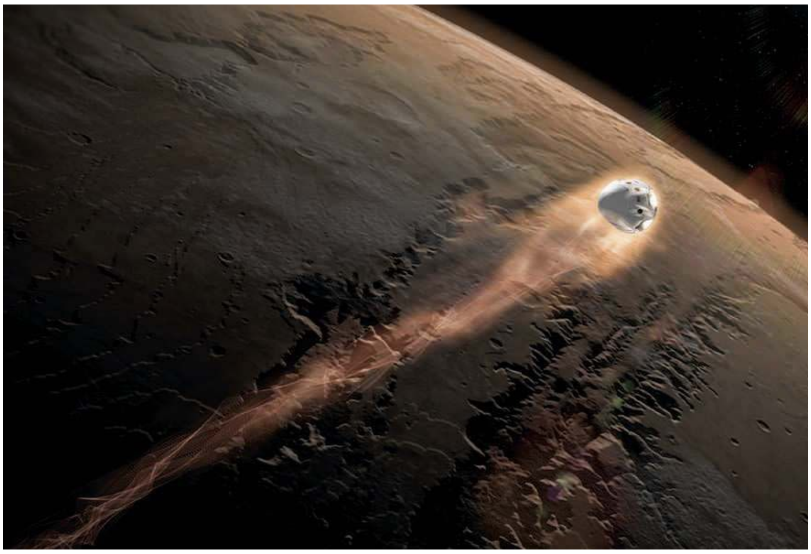
Following on from Von Braun

Although his ideas pre-date those currently being proposed by various billionaires, Aldrin is certainly not the first to consider how to carry out a manned mission to Mars. Dr Wernher von Braun, developer

▼ Establishing a colony on Mars could reduce the cost of subsequent missions to the Red Planet



ISTOCK X 2, SPACE X, CAT VINTON/CATVPHOTOGRAPHY.CO.UK, CHUCK DAVIS/DRACONOIR



▲ **SpaceX is one of the private companies working on plans to send humans to Mars**

of the Saturn V rocket, briefed NASA's Space Task Group just after the Moon landings on a plan to land two expedition spacecraft on Mars in 1982. "Werner von Braun's vision of Mars exploration was a tremendous inspiration to many of us," says Aldrin. "But von Braun was really interested in using very large rockets. I think we can get to Mars without the same reliance on state-developed and operated rockets." Aldrin's plan also differs from Von Braun's in its level of reusability.

Ambitious space exploration plans always come with a huge caveat: politics. Aldrin was recently at the White House, standing alongside President Donald Trump as he signed an executive order re-establishing the National Space Council after its 24-year hiatus, but he's not getting too carried away with that decision. "I don't expect the Space Council to fundamentally change the US space programme by itself. But it will really become critical if the administration decides to fundamentally rethink major aspects of our civil and national space programmes," says Aldrin. That's what he's hoping for.

Aldrin will be keeping a close watch on what President Trump says on 24 July 2019 when the world marks 50 years since Aldrin and Neil Armstrong set foot on the Moon. "I'm personally very committed to the idea that the President should, and indeed must, announce a major US commitment to Mars permanence by the 50th anniversary," he says. "It's essential to force us to make the hard choices we must make in order to get to Mars in the next 20 years." Ⓢ

ABOUT THE WRITER

Jamie Carter is the author of *A Stargazing Program for Beginners: A Pocket Field Guide* and edits WhenIsTheNextEclipse.com

A RED CARPET FOR THE RED PLANET

How Aldrin is using his lunar legacy to help the next generation get to Mars

▲ **The 2017 Apollo 11 Anniversary Gala took place underneath a Saturn V rocket**

▲ **From left: Walt Cunningham, Michael Collins, Buzz Aldrin and Harrison 'Jack' Schmitt**

▲ **Funds raised at the gala will go to projects including the Giant Mars Map school tours**

Although Aldrin thinks that landing on Mars would be a far greater achievement than the Apollo 11 landing, he knows the lunar mission he took part in still gets space fans excited. So in July, his ShareSpace Foundation staged an Apollo 11 Anniversary Gala at the Kennedy Space Center in Florida to raise funds for children's education projects.

It was the first event of a three-year fundraising campaign that builds towards the 50th anniversary of Apollo 11 in 2019, when Aldrin hopes the US will commit to a manned Mars mission. The event raised almost $200,000 (£152,000) for the ShareSpace Foundation's educational projects. One of those projects is the Giant Mars Map, a 8x8m map of the Martian surface, with the landing sites of all Mars rover missions marked upon it. It's already being taken around schools to inspire the next generation to aim for Mars.

The money was raised through ticket sales and auctions. Aldrin sold a signed, framed sample of Kapton foil from the Apollo 11 Command Module for $4,500 (£3,400). But perhaps the most impressive lot was a First Day Cover signed by all three Apollo 11 Crew members that had flown to the surface of the Moon. It fetched $42,500 (£32,400).

Aldrin was joined on stage at the gala by Apollo 11 command module pilot General Michael Collins, in a rare public appearance, as well as Walt Cunningham (Apollo 7), Harrison 'Jack' Schmitt (Apollo 17) and Jeff Bezos, founder of Blue Origin. Bezos collected a Buzz Aldrin Space Innovation Award for his work on reusable rockets.

The event also saw the launch of the Buzz Aldrin Space Foundation (BASF) by his son Andrew. "Somewhere out there tonight is a kid who will be the first human on Mars," he said. "She just doesn't know it yet."

Modern Astronomy

September Spotlight!

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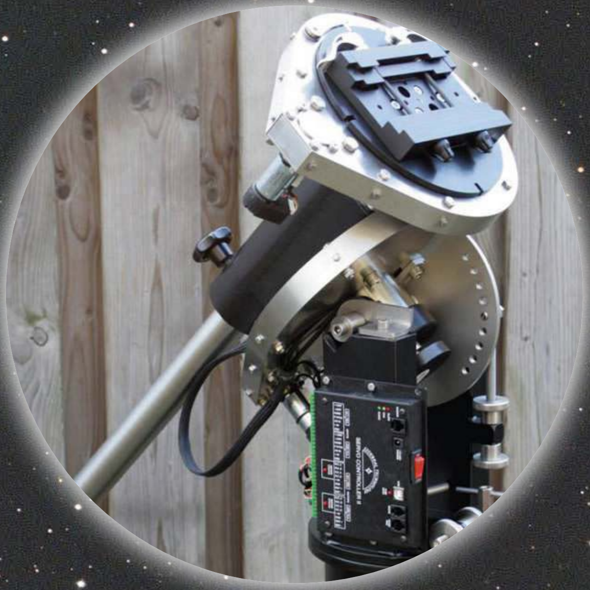

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PETE LAWRENCE

PLUS

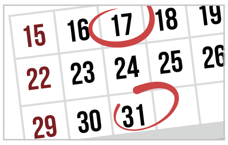
Stephen Tonkin's
BINOCULAR TOUR
Turn to page 60 for six of this month's best binocular sights

WRITTEN BY
PETE LAWRENCE

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

THE SKY GUIDE
SEPTEMBER

The spectacularly bright planet Venus pays a close call to the delicate collection of stars in Cancer known as the Beehive Cluster at the start of the month. The planet will clip the southern boundary of the cluster, creating a sight that will be worth setting the alarm early for.



SEPTEMBER **HIGHLIGHTS**

Your guide to the night sky this month

FRIDAY 1

This morning and tomorrow morning the blazingly bright planet Venus can be seen passing just to the south of the Beehive Cluster, M44 in Cancer.

The Aurigid meteor shower reaches its peak zenithal hourly rate of six meteors per hour tonight.

TUESDAY 5

Neptune reaches opposition and is visible all night long. It is in Aquarius, close to mag. +3.7 Lambda (λ) Aquarii.

Look out for Mars very low and close to mag. +1.4 Regulus (Alpha (α) Leonis) in the morning sky.

WEDNESDAY 6

Being September, some sources would list today's full Moon as the Harvest Moon. However, this one occurs 16 days from the northern hemisphere's autumn equinox. The full Moon on 5 October is closer (13 days from the equinox) making it the true Harvest Moon of 2017.

SUNDAY 10

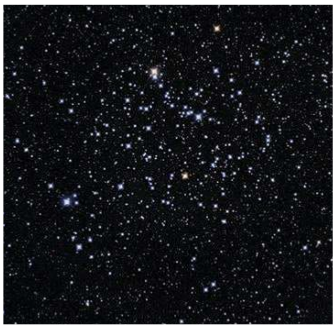
Today mag. +0.2 Mercury is close to mag. +1.4 Regulus (Alpha (α) Leonis). Look for the planet and star in the pre-dawn sky. They'll appear to be separated by just 39 arcminutes.

TUESDAY 12

Mercury reaches greatest western elongation. It will appear separated from the Sun by almost 18° in the morning sky.

THURSDAY ▶ 14

The 41%-lit waning crescent Moon is a little under 6° south of open cluster M35 in Gemini in the early hours.



SATURDAY ▶ 16

Mag. –0.7 Mercury is 28 arcminutes to the west of mag. +1.8 Mars in this morning's sky. The planets continue to close in on one another throughout the day, appearing just 3.5 arcminutes apart at 19:00 BST (18:00 UT) when they are close to setting.

WEDNESDAY 20

Mag. –3.8 Venus appears 28 arcminutes north of mag. +1.4 Regulus (Alpha (α) Leonis) in this morning's sky. This is also the date of September's new Moon, making this a great time to take our deep-sky tour (page 62).

FRIDAY ▶ 22

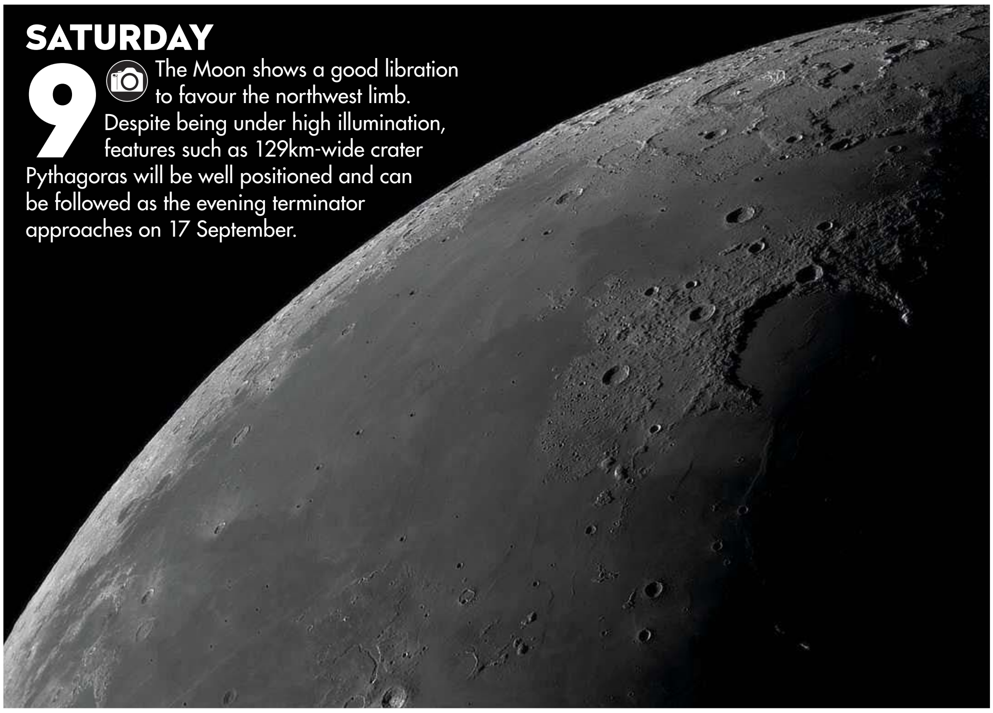
Jupiter is close to the 6%-lit waxing crescent Moon in this evening's sky. The mag. –1.5 planet is 5° west of the Moon at 19:45 BST (18:45 UT).

Today is the northern hemisphere autumn equinox.

◀ TUESDAY 26

The beautiful planet Saturn can be seen around 3.5° south-southeast of tonight's 37%-lit waxing crescent Moon. View them at 21:00 BST (20:00 UT).

PETE LAWRENCE X 8



SATURDAY

9 The Moon shows a good libration to favour the northwest limb. Despite being under high illumination, features such as 129km-wide crater Pythagoras will be well positioned and can be followed as the evening terminator approaches on 17 September.

SUNDAY

17 Mercury appears 20 arcminutes to the east of Mars this morning. Catch them both around 90 minutes before sunrise – that's 05:20 BST (04:20 UT) from the centre of the UK.

MONDAY

18 This morning's 4%-lit waning crescent Moon is 0.5° south of mag. +1.4 Regulus (Alpha (α) Leonis). Mercury, Mars, the crescent Moon and Venus will also appear in a line.

TUESDAY

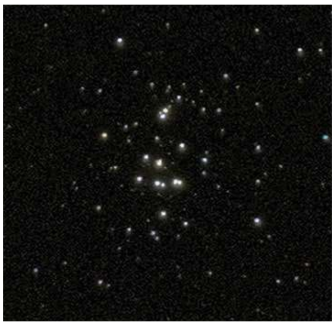
19 The linear planetary alignment continues into this morning with a really thin 1.3%-lit waning crescent Moon, just visible before sunrise.

SUNDAY

24 The 20%-lit waxing crescent Moon, low in the southwest at 20:00 BST (19:00 UT), shows a favourable libration for the southeast limb. It also occults mag. +3.9 Gamma (γ) Librae at 19:48 BST (18:48 UT), reappearing at 20:55 BST (19:55 UT).

MONDAY ▶

25 Mag. +12.7 comet 24P/Schaumasse can be seen against the northern region of the Beehive Cluster, M44 in Cancer. Catch them together in the early hours.



◀ WEDNESDAY

27 The Lunar X will be visible at around 21:20 BST (20:20 UT). It's fascinating to watch the letter 'X' form as the dawn terminator approaches the region, roughly one-third of the way up from the southern limb.

FAMILY STARGAZING – 20 SEP

The Great Square of Pegasus is a large, prominent pattern of stars, approximately square in shape. On a moonless night, identify the pattern – its sides are about 1.5 times the width of an adult's fist at arm's length – using our all-sky-chart on page 54. Set the challenge to count the stars within its boundary. Young eyes should find it easier to pick out the fainter stars. The total can be used to gauge your sky transparency. Not including the corners, a count of 0-2 is poor, 3-7 average, 8-11 good and 12 or more excellent. Conditions and totals may vary between nights. www.bbc.co.uk/cbeebies/shows/stargazing

NEED TO KNOW

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

FAMILY FRIENDLY Objects marked with this icon are perfect for showing to children

NAKED EYE Allow 20 minutes for your eyes to become dark-adapted

PHOTO OPPORTUNITY Use a CCD, planetary camera or standard DSLR

BINOCULARS 10x50 recommended

SMALL/ MEDIUM SCOPE Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing a scope.

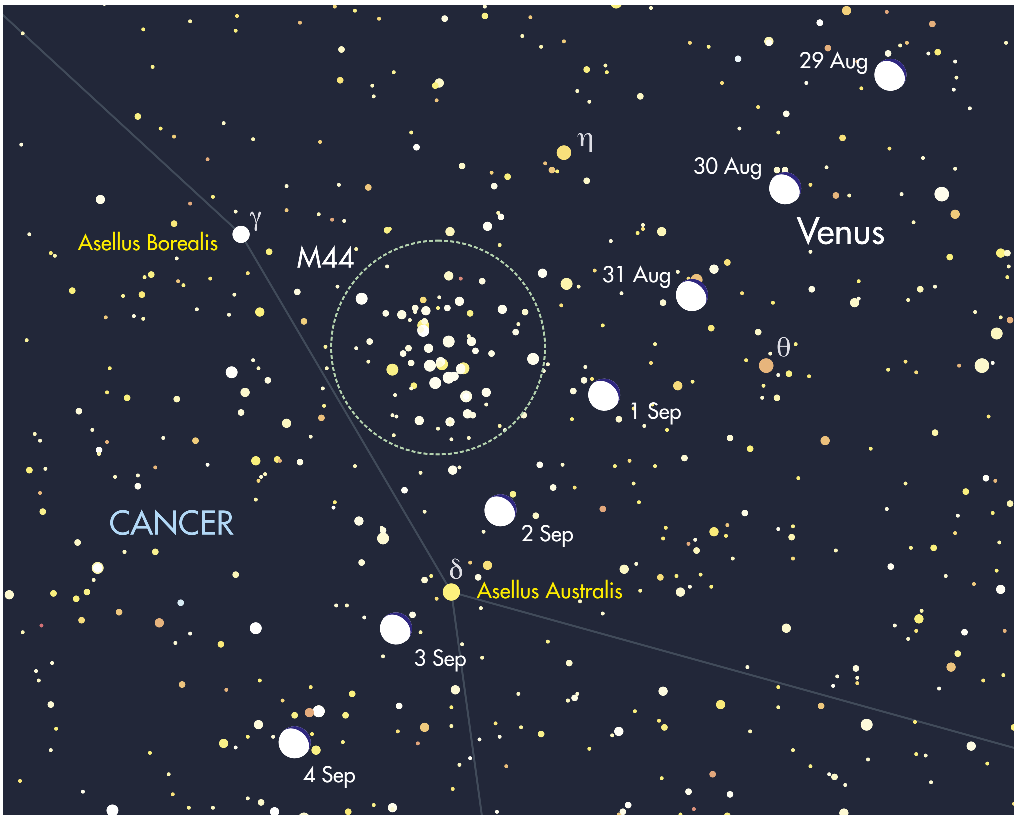
THE BIG THREE

The three top sights to observe or image this month

DON'T MISS

Venus and M44

WHEN: 1-3 September; also look for the planet on 18-21 September for its meeting with Regulus



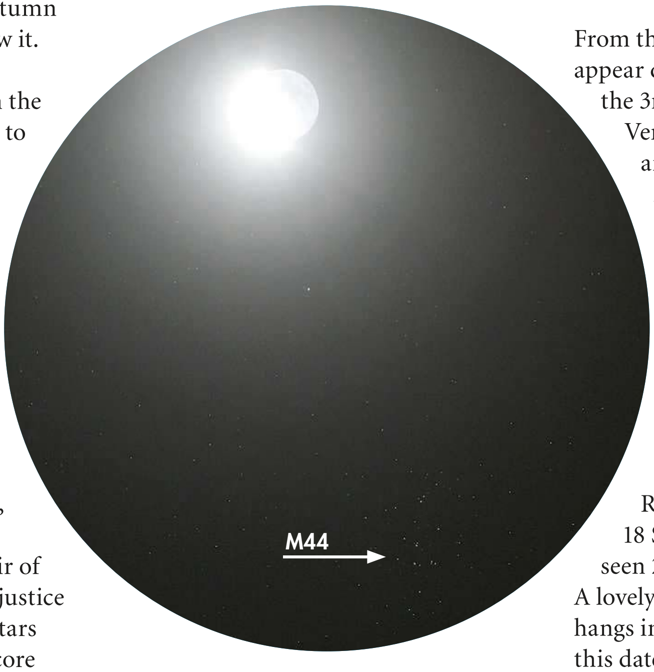
▲ The location of Venus at 04:30 BST (03:30 UT) as it passes the Beehive Cluster at the end of August and in the first few days of September. They will be low in the east-northeast at this time

Venus makes a close pass along the southern edge of the Beehive Cluster, M44 in Cancer, at the start of the month. There's something quite compelling about seeing Solar System objects close to deep-sky ones. Comets against distant galaxies, or planets passing through or near familiar clusters create a wonderful opportunity to contemplate the three-dimensional nature of our skies.

The Beehive Cluster is a familiar object in the spring, but during autumn additional effort is required to view it. It rises in the northeast around 03:30 BST (02:30 UT) as seen from the centre of the UK and takes a while to climb out of the thick, often hazy layer of atmosphere close to the horizon. However, brilliant Venus will fare better.

The cluster is ranked at mag. +4.0, although it's harder to spot with the naked eye than this figure suggests. Typically, under reasonably dark conditions, M44 can be seen as a hazy smudge with direct vision. It has an appreciable apparent size, measuring approximately 1.5° across. It is best seen through a pair of binoculars, which do both its size justice and help to bring out the myriad stars that appear to swarm around the core like bees around their hive.

On 1 September Venus sits 1.25° southwest of the cluster. From the UK this places Venus below and right of the cluster's core. Again, binoculars are an ideal way of getting a good view, a typical pair having a sufficiently large field to contain the cluster and planet at the same time.



▲ Located near the ecliptic, M44 is no stranger to Solar System visitors; here it is with an overexposed Moon

PETE LAWRENCE X 4

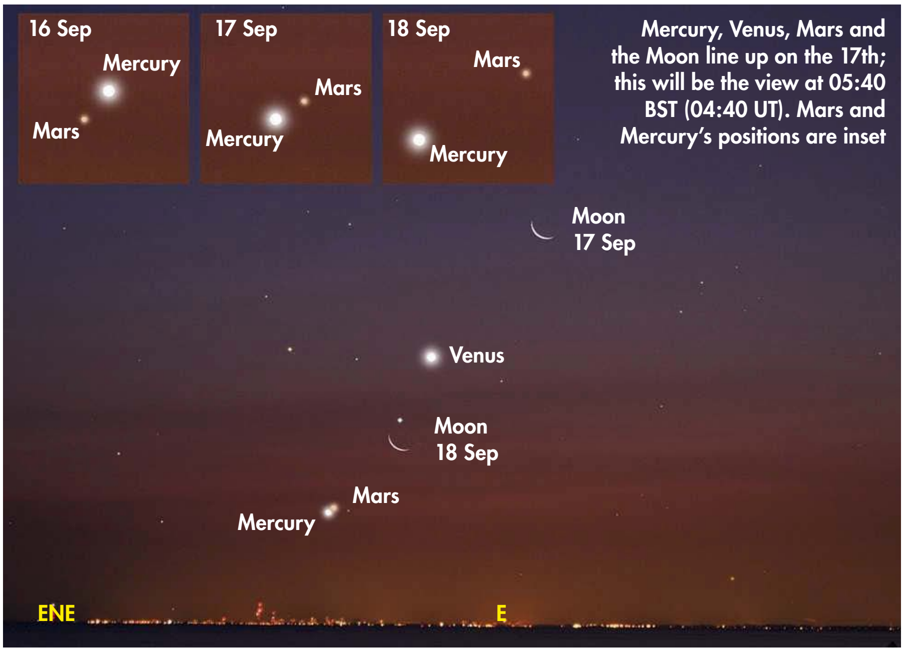
On 2 September, Venus appears 1.5° east of south of the cluster's centre. From the UK this makes the planet appear directly below the cluster. By the 3rd the main event is all but over, Venus now appearing 2° from M44 and 0.5° east of mag. +3.9 Asellus Australis (Delta (δ) Cancri).

If you get clear skies at the start of the month, try to catch the pair just after they rise and keep watch over the next hour until the brightening twilight washes the cluster's stars from view.

Later in the month Venus passes very close to mag. +1.4 Regulus (Alpha (α) Leonis). On 18 September the planet can be seen 2.3° northwest of the star. A lovely 4%-lit waning crescent Moon hangs immediately below Regulus on this date. Venus appears to close in on the star over the next couple of mornings, sitting 0.5° north-northeast of it on the morning of 20 September. This presents an opportunity to try and spot Regulus during daylight using a telescope. Lock onto Venus as the Sun rises and see if you can spot the star nearby.

Mercury meets Mars

WHEN: Closest approach occurs in the morning skies of 16 and 17 September



Mercury, Venus, Mars and the Moon line up on the 17th; this will be the view at 05:40 BST (04:40 UT). Mars and Mercury's positions are inset

Mercury rises approximately 90 minutes before the Sun on 10 September and should be relatively easy to see at mag. +0.2. On this date it is 38 arcminutes south-southwest of mag. +1.4 Regulus (Alpha (α) Leonis). If you manage to take a photograph of the pair, you'll also want to catch the spectacular meet-up between Regulus and Venus on 20 September.

On 10 September, mag. +1.8 Mars can be seen 3° east of Regulus. From the UK this places it below and left of the star. Over the next few mornings Mercury and Mars appear to converge. Visible approximately 90 minutes before sunrise low in the east, on 15 September, mag. +3.8 Rho (ρ) Leonis, mag. +1.8 Mars and –0.6 Mercury form a right-angled triangle, with Mars at the right-angle. The planets appear 1.2° apart at this time.

On 16 September the separation will be 28 arcminutes, with Mars, Mercury and Rho Leonis now forming a thin isosceles triangle. If you can keep with the planets as the Sun rises, under very clear skies it may be possible to follow them in daylight as they continue to converge. As they approach their setting point around 19:00 BST (18:00 UT, times for the centre of the UK) they will appear just 3.5 arcminutes apart.

On 17 September the apparent separation is 20 arcminutes. By the 17th, Mercury will have brightened to mag. –0.8 making it easier to spot despite losing altitude. On 18 September, the celestial meeting ends, the apparent separation having increased to 1.2°.

Although it's not impossible, it's unusual to have perfectly clear skies for morning observing sessions during September. Despite this, having a range of dates to pick from will hopefully ensure you see something of this impressive early morning show.

Comet 24P/Schaumasse and the Beehive

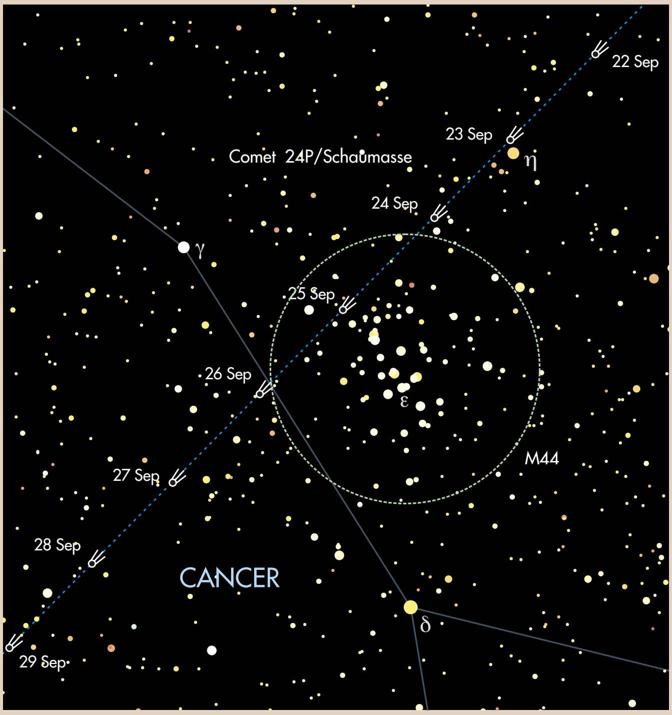
WHEN: 24-26 September, from 04:00 BST (03:00 UT)

Venus is not the only Solar System object passing close to the Beehive Cluster in Cancer, M44, this month. Comet 24P/Schaumasse is also in the vicinity, travelling in front of the northern part of the cluster between 24-26 September.

When Venus passed south of the cluster at the start of the month the stars of the Beehive were completely outshone by the blazing light of the planet. With 24P/Schaumasse the tables are turned because the comet is predicted to be a 12th-magnitude object at this time. This means that it's best suited to at least an 8-inch telescope or as a target for astrophotography.

The cluster rises above the northeast horizon just after 01:30 BST (00:30 UT) and manages to attain an altitude of about 30° at 05:00 BST (04:00 UT) in a dark sky, astronomical twilight beginning shortly after this time.

On 24 September at 04:00 BST (03:00 UT), the comet is 1° to the northwest of the cluster's centre. On the morning of 25 September, the apparent separation will have decreased to just 0.5°, the comet lying due north of the cluster's centre. Then on the morning of 26 September, the separation will have increased to 1° again, with the comet being found to the east-northeast.



▲ Comet 24P/Schaumasse will cut through the Beehive Cluster, appearing as a faint smudge passing between the sharp cluster stars

THE NORTHERN HEMISPHERE IN SEPTEMBER

KEY TO STAR CHARTS

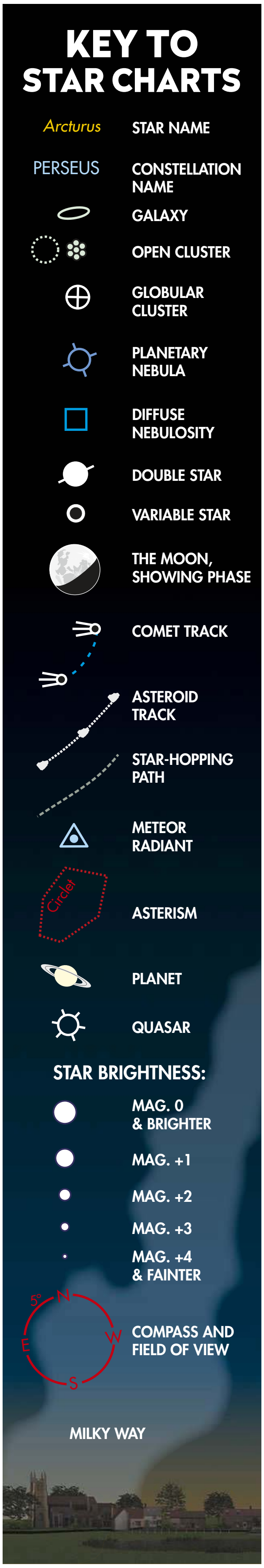


CHART: PETE LAWRENCE

WHEN TO USE THIS CHART

1 SEP AT 01:00 BST
15 SEP AT 00:00 BST
30 SEP AT 23:00 BST

On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.

SUNRISE/SUNSET IN SEPTEMBER*

DATE	SUNRISE	SUNSET
1 Sep 2017	06:19 BST	19:59 BST
11 Sep 2017	06:36 BST	19:35 BST
21 Sep 2017	06:54 BST	19:10 BST
1 Oct 2017	07:11 BST	18:46 BST

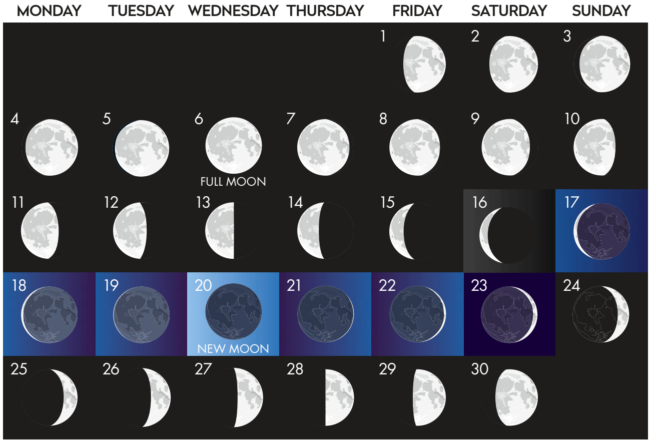
MOONRISE IN SEPTEMBER*

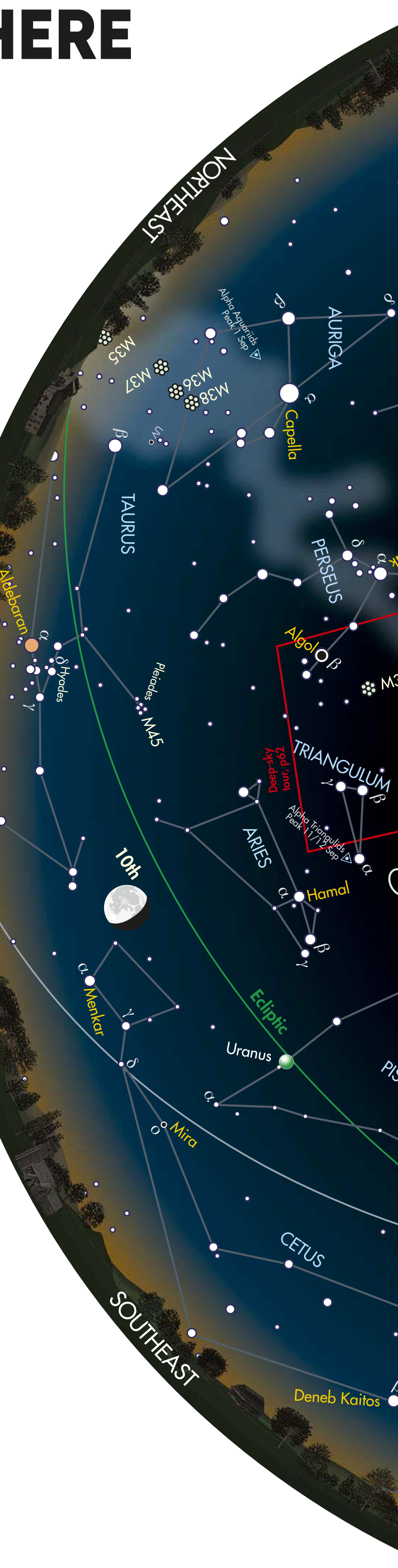
MOONRISE TIMES

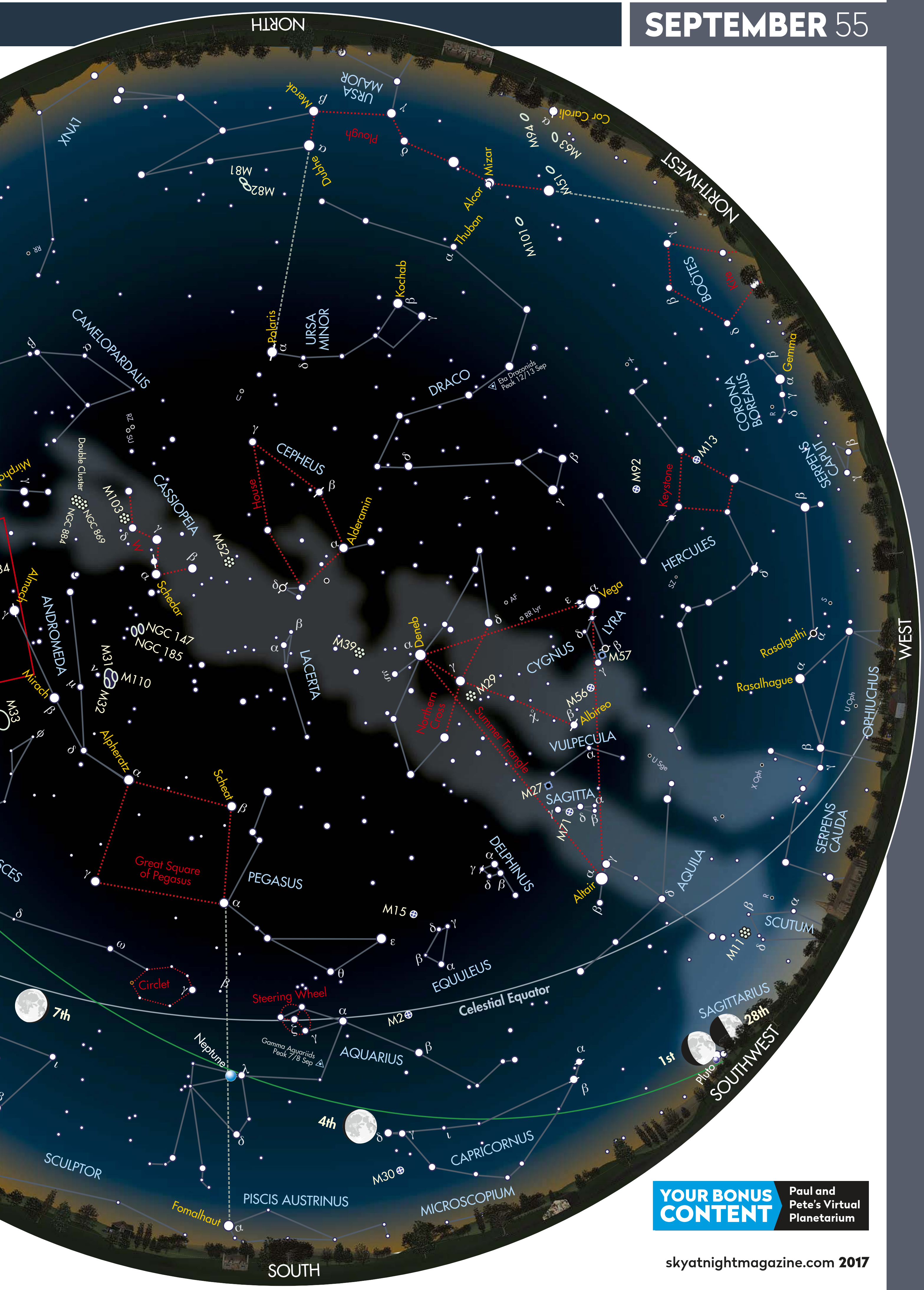
1 Sep 2017, 17:26 BST	17 Sep 2017, 03:04 BST
5 Sep 2017, 19:42 BST	21 Sep 2017, 08:03 BST
9 Sep 2017, 21:20 BST	25 Sep 2017, 12:34 BST
13 Sep 2017, 23:48 BST	29 Sep 2017, 16:04 BST

*Times correct for the centre of the UK

LUNAR PHASES IN SEPTEMBER







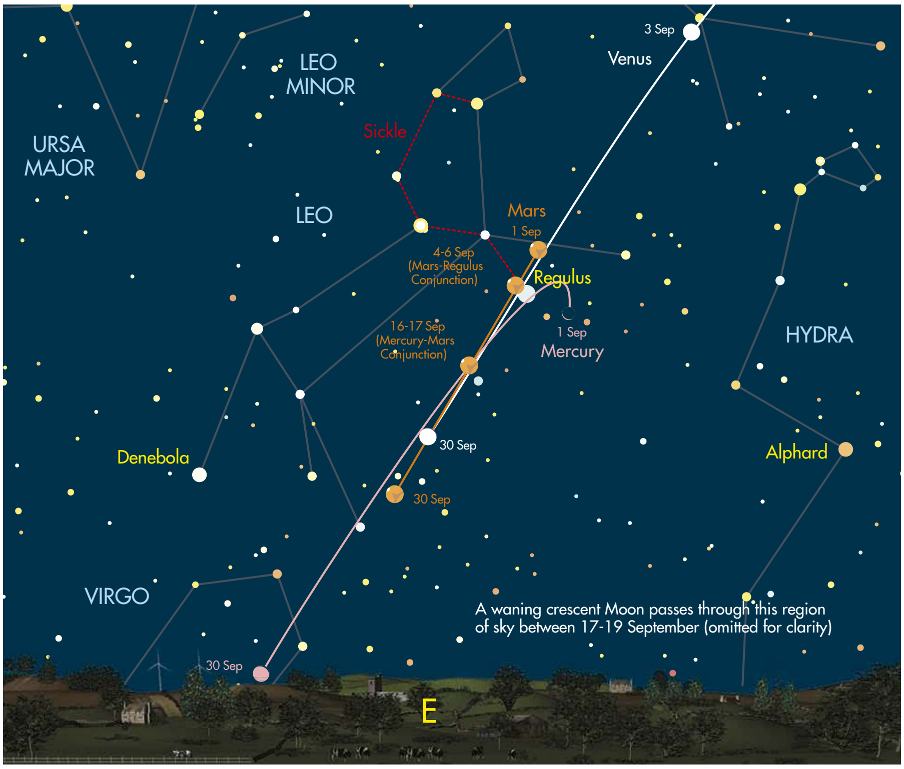
YOUR BONUS CONTENT
Paul and Pete's Virtual Planetarium

THE PLANETS

PICK OF THE MONTH

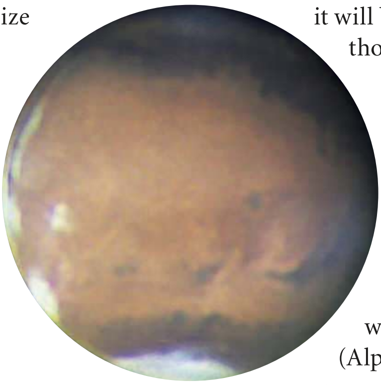
MARS

BEST TIME TO SEE: 16 September, 05:30 BST (04:30 UT)
ALTITUDE: 2.5° (low)
LOCATION: Leo
DIRECTION: East-northeast
FEATURES: Colour, dark surface markings, bright polar caps, weather
EQUIPMENT: 6-inch or larger telescope


3 Sep
Venus
LEO MINOR
URSA MAJOR
Sickle
LEO
Mars
1 Sep
4-6 Sep (Mars-Regulus Conjunction)
Regulus
16-17 Sep (Mercury-Mars Conjunction)
1 Sep
Mercury
HYDRA
Denebola
30 Sep
30 Sep
Alphard
VIRGO
A waning crescent Moon passes through this region of sky between 17-19 September (omitted for clarity)
30 Sep
E

▲ Mars and Mercury cross paths; constellation positions shown for 05:30 BST on 30 September

Mars is a morning object gradually pulling away from the Sun's glare in September. Telescopically, it's rather challenging. It does not attain a decent altitude and appears rather small through the eyepiece. The planet is on the far part of its orbit relative to Earth and this renders its disc small. At present it has a similar apparent size to the planet Uranus.



▲ Mars will appear small, its disc about the same size as Uranus's

PETE LAWRENCE X 3

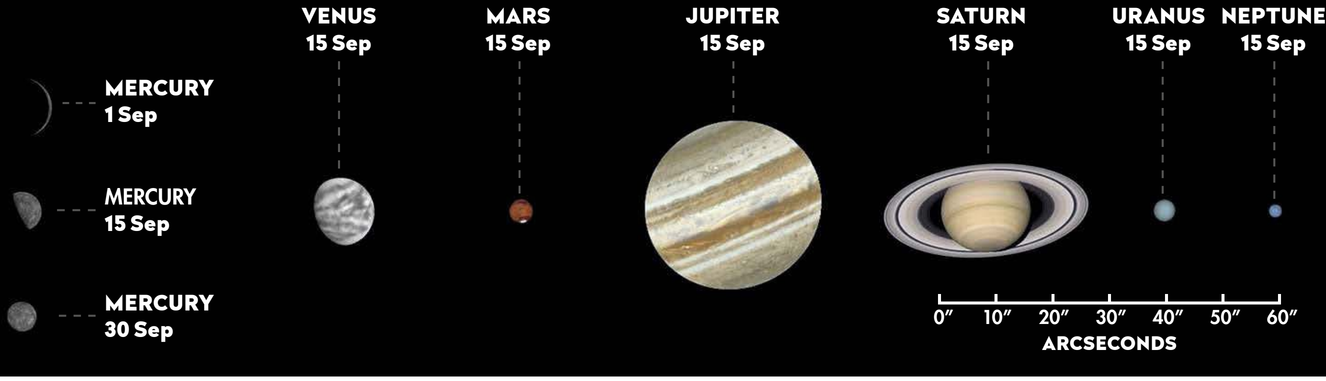
However, it's good to see Mars on the western side of the Sun, a course that will take it towards its next opposition close to the end of July 2018. This will be a perihelic opposition, one which occurs when Mars is in a part of its orbit that takes it closer to the Sun. As a consequence this will be a favourable situation for earthbound observers too, although it will be low in the sky for those of us in the UK.

This month the emphasis is more on the naked eye and binocular appearances of the Red Planet. Mars is mag. +1.8 and forms an interesting pattern with mag. +1.4 Regulus (Alpha (α) Leonis) and mag. +1.5 Mercury from 5-8 September. Look to the east-northeast from about 05:20 BST (04:20 UT). There's a really close encounter between Mars and a much brighter Mercury (now mag. –0.7) on 16 and 17 September. The two planets will have an apparent separation of 27 arcminutes on the 16th and 21 arcminutes on the 17th. On the morning of 17 September, Mars and Mercury fall into a straight line with Regulus, Venus and a slender waning crescent Moon that's just 10% lit – you can read more about that encounter in this month's Big Three (page 52).

It's fascinating to watch how these patterns of planets, bright stars and the Moon appear to change over subsequent mornings. By 30 September, Mars and a dazzling mag. –3.8 Venus will appear to be 2.7° apart. This comes ahead of a further close encounter set to occur in the first week of October.

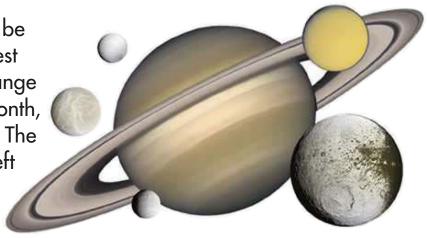
THE PLANETS IN SEPTEMBER

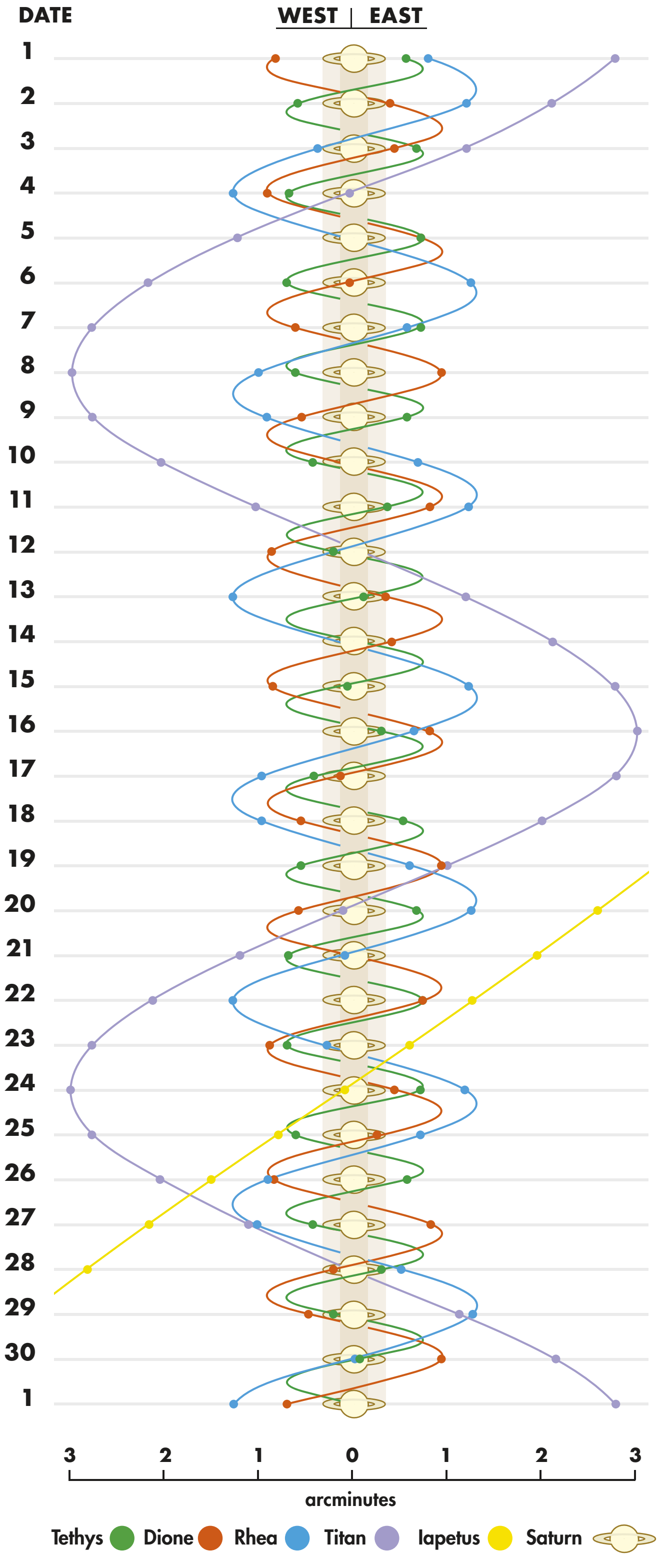
The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



SATURN'S MOONS
SEPTEMBER

Using a small scope you'll be able to spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.





MERCURY

BEST TIME TO SEE:
16 September, 18:00 BST (17:00 UT)
ALTITUDE: 7.5° (low)
LOCATION: Leo
DIRECTION: East

Mercury is a morning object that has a close encounter with mag. +1.4 Regulus (Alpha (α) Leonis) on the 10th. Mag. +0.2 Mercury appears 38 arcminutes from the star. After greatest western elongation on the 12th (Mercury will be 17.9° from the Sun) the planet swings sunwards, chasing Mars as it goes. As it enters a brighter part of the sky, Mercury compensates by appearing brighter itself. On the 19th, at mag. –0.9, it shares the sky with mag. +1.8 Mars and mag. –3.8 Venus, 2° and 12° west respectively. You may also be able to see a 1%-lit waning crescent Moon 3.6° east of the planet just before sunrise. On the 23rd, it is mag. –1.1 and sits at one end of a line also formed by Mars, Jupiter and Regulus.

VENUS

BEST TIME TO SEE:
1 September, from 04:00 BST (03:00 UT)
ALTITUDE: 5° (low)
LOCATION: Cancer
DIRECTION: East-northeast

On the 1st, mag. –3.9 Venus is 1.5° south of the centre of the Beehive Cluster, M44 in Cancer. It's a spectacular sight through binoculars or a telescope using a low power. Telescopically Venus appears 11.7 arcminutes across on 1 September, with a phase of 88%. On the 20th it passes mag. +1.4 Regulus (Alpha (α) Leonis), by less than 0.5°. At month end, Venus is 3.3° from Mars and, through a telescope appears 11 arcseconds across and 90% lit.

JUPITER

BEST TIME TO SEE:
22 September, 19:20 BST 18:20 UT
ALTITUDE: 4° (low)
LOCATION: Virgo
DIRECTION: West-southwest

Jupiter is too low for serious telescopic observation, located in the evening twilight close to the west-southwest horizon just after sunset. A thin, 6%-lit waxing crescent Moon is 5° above and left of Jupiter on the evening of 22 September.

SATURN

BEST TIME TO SEE:
1 September, from 20:45 BST (19:45 UT)
ALTITUDE: 14°
LOCATION: Ophiuchus
DIRECTION: South

Saturn is past its best for 2017 and during September slowly dims from mag. +0.4 to +0.5. A scope will shows the planet's beautiful rings currently tilted over by 27°. The planet is 3.5° below a 37%-lit waning crescent Moon on the evening of the 26th; look low in the southwest around 21:00 BST (20:00 UT)

URANUS

BEST TIME TO SEE:
30 September, from 02:20 BST (01:20 UT)
ALTITUDE: 47°
LOCATION: Pisces
DIRECTION: South

Uranus is well placed and reaches its highest point in the sky in darkness all month. It's mag. +5.7 and approximately 1° north of mag. +4.3 Omicron (ο) Piscium.

NEPTUNE

BEST TIME TO SEE:
5 September, 01:08 BST (00:08 UT)
ALTITUDE: 29°
LOCATION: Aquarius
DIRECTION: South

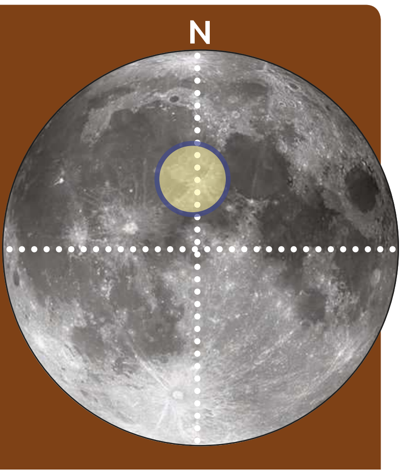
Neptune reaches opposition on 5 September and remains visible all night long for most of the month. By month end Neptune is 39 arcminutes southeast of mag. +3.7 Lambda (λ) Aquarii. Binoculars are required to see the mag. +7.8 planet; a telescope will show its tiny 2.3-arcsecond disc and its blue hue. The full Moon on 6 September will be 2.3° southwest of Neptune.

YOUR BONUS CONTENT Planetary observing forms

MOONWATCH

MONTES APENNINUS

TYPE: Mountain Range
SIZE: 600km long, 150km wide
LONGITUDE/LATITUDE: 20.1°W, 9.6°N
AGE: 3.2-3.85 billion years
BEST TIME TO SEE: First quarter (28-29 September) or six days after full Moon (12-13 September)
MINIMUM EQUIPMENT: 10x binoculars



> ***"Mons Huygens is the highest lunar mountain, but not the highest point"***

There are many lunar mountain ranges visible from Earth but the sheer majesty of the lunar Apennines takes some beating. This 600km arc, bordering the Mare Imbrium, contains the Moon's highest peak – Mons Huygens, rising to 5.5km. The southern end of the range begins just north of 60km-wide crater Eratosthenes. The range curves gently east, climbing to its first peak, Mons Wolff, at 3.5km high. A deep valley runs adjacent to Wolff, cutting the range in a northwest-southeast direction. Across the way sits the peak of Mons Serao, cradling the 5km crater Wallace C. The Apennine arc continues northeast marked by number of lumps and bumps, but is interrupted by surprisingly few craters considering the age of the range. Wallace D is the only serious contender here, although at 4km across it's hardly a major intrusion.

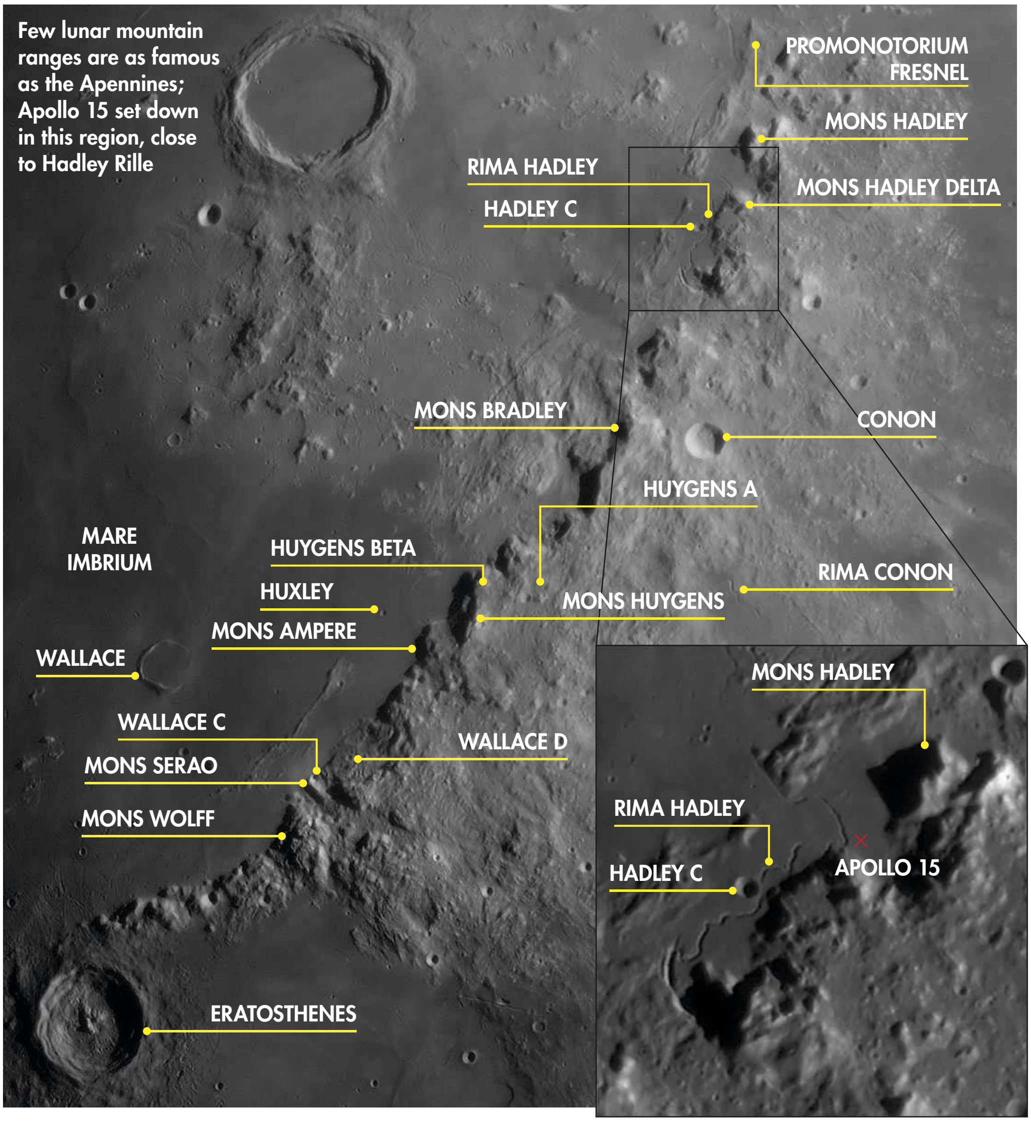
The next major Apennine peak is 3km high Mons Ampere, which juts out slightly into the Mare Imbrium towards 3km Huxley, formerly Wallace B. To the east of Mons Ampere we see the ridge of 5.5km-high Mons Huygens. Its ridge runs for 28km from the southeast of Mons Ampere, curving to the north where it partially juts out in a region once referred to as Huygens Beta. Immediately east of Mons Huygens is Huygens A, a 6km crater named after the mountain.

Although Mons Huygens is the highest mountain on the Moon, it is not the highest point. This seemingly contradictory statement arises due to a region on the Moon's far side, where the surface height deviates from the mean lunar radius by 10.8km. This region is simply an elevated surface and not a true mountain, so Mons Huygens retains its title.

An impressive set of jutting northwest facing slopes leads the eye northeast towards 4.2km-high Mons Bradley. This is easily recognised, lying 40km west of the centre of 22km crater Conon. Also look out for the snake-like form of Rima Conon 80km to the south.

The Apennines continue northeast towards Promonotorium Fresnel, a transition between the Apennine and Haemus mountain ranges. Situated between Promonotorium Fresnel and Mons Bradley is the Mons Hadley region. Here we find an impressive set of peaks including 3.5km-high Mons Hadley Delta, a distinctive mountain that formed part of the dramatic backdrop to the Apollo 15 landing site.

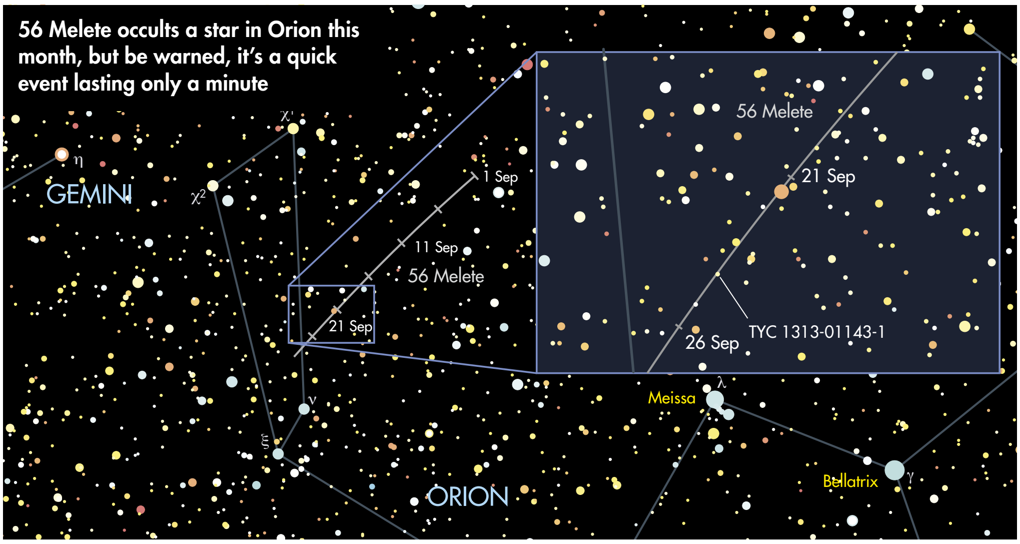
North of Mons Hadley Delta is the imposing form of 4.2km high Mons Hadley. This towers over a flat lava plain to the southwest, where Apollo 15 landed. The region is defined by an amazing sinuous rille known as Rima Hadley. This is visible in 8-inch or larger instruments, snaking its way across the lava field for a distance of approximately 70km. The 6km crater Hadley C sits midway along the rille, providing a navigational guide for identifying the area with smaller telescopes.


Few lunar mountain ranges are as famous as the Apennines; Apollo 15 set down in this region, close to Hadley Rille

PETE LAWRENCE X 3

COMETS AND **ASTEROIDS**

56 Melete – a minor planet that offers us the chance to do some serious science



56 Melete occults a star in Orion this month, but be warned, it's a quick event lasting only a minute

Minor planet 56 Melete is a main belt asteroid discovered 160 years ago on 9 September 1857. It takes 4.18 years to orbit the Sun, its elliptical orbit bringing it in as close as 1.97 AU to our star and out as far as 3.21 AU. It's a dark object, 129km across, its light curve showing a small variation in brightness of 0.15 magnitudes caused by its rotation. The repeat of this curve, and hence the asteroid's rotation period, is 18.15 hours.

Occasionally asteroids appear to pass in front of stars, and 56 Melete was observed doing so in 1997 and 2002. Such events are important because the occultation track – where it can be seen from Earth – is finite. Within the track, accurate timings can help derive the profile width of the asteroid. If enough observers record timings within the track path, it is possible to add all of their occultation results together and built an approximate profile of the asteroid's shape.

Another occultation is predicted to occur during the morning of 24 September, when 56 Melete will occult the mag. +11.0 TYC 1313-01143-1, which is in the northern part of Orion, near the Hunter's 'club'. The occultation track passes across the south of the Republic of Ireland, much of Wales and central England. The event is predicted to occur between 04:05-04:06 BST (03:05-03:06 UT) on 24 September. At that time, 56 Melete will be mag. +13.8 and cause the star to dim by 2.9 magnitudes.

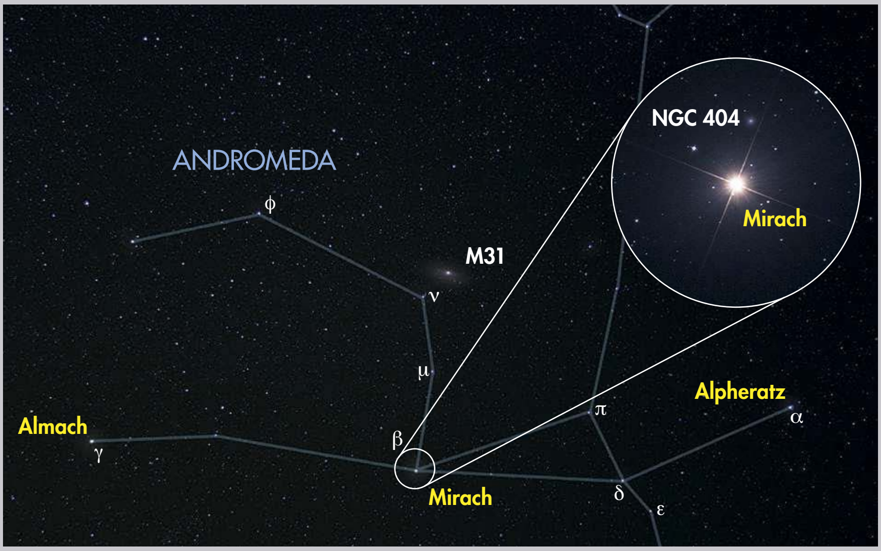
As asteroids go, 56 Melete is pretty faint, remaining at mag. +13.8 all month long. Despite this, imagers should be able to pick it up as it passes from the southeast corner of Taurus into the northern part of Orion. If you are located within the occultation track, this is a great opportunity to do some quite important science.

STAR OF **THE MONTH**

Mirach – the haunted semi-regular varaible

Mirach (Beta (β) Andromedae) is halfway along Andromeda's body, between Alpheratz (Alpha (α) Andromedae) and Almach (Gamma (γ) Andromedae). The name Mirach probably results from a corruption of mi'zar, meaning girdle or waist-cloth. Mirach and Alpheratz have the same average brightness of mag. +2.06, but look markedly different because Mirach is a red giant and Alpheratz a hot blue star.

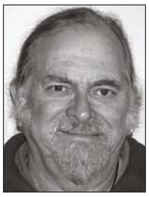
Mirach is 197 lightyears away and 1,900 times more luminous than the Sun. Its radius is estimated at around 0.4 AU, or 85 times larger than the Sun, giving it a circumference equivalent to the orbit of Mercury. As the star is approaching the end of its life its core probably consists of helium or carbon. As is common with old red giants, Mirach's light is inconstant, and it's classed as a semi-regular variable. The changes in brightness are small, ranging between +2.01 to +2.10.



▲ **Mirach and NGC 404 appear close as a line of sight effect; the galaxy is 51,000 times farther**

Like many stars, Mirach is not alone and has a 14th-magnitude main-sequence companion that is 60,000 times dimmer than Mirach itself. Their orbits bring them physically to within 40 times the Sun-Pluto distance of one another. From Mirach the companion would appear as bright as Venus appears from Earth. Mirach would appear 120 times brighter than the full Moon from the companion.

Through the eyepiece Mirach has an additional deep sky companion in the form of the isolated dwarf lenticular galaxy, NGC 404. The apparent separation between star and galaxy is just 7 arcminutes giving NGC 404 the appearance of a lens flare caused by Mirach. Known informally as Mirach's Ghost, one of the biggest hurdles to seeing it is the brightness of Mirach itself.



STEPHEN TONKIN'S

BINOCULAR TOUR

September offers a debated globular, a dark lizard and the delight of a famous asterism

☑ Tick the box when you've seen each one

1 THE SUMMER BEEHIVE

10x 50 Our first target's brighter stars form the word 'HI'. Locate mag. +2.7 Cebalrai (Beta (β) Ophiuchi) and you will see IC 4665, the Summer Beehive, in the same field of view. It's just over 1° northeast of the star. You should be able to resolve a dozen or so stars with a pair of 10x50s, including the curved chain of hot white stars that forms part of the letter H. This is a relatively young cluster, being less than 40 million years old. ☐ **SEEN IT**

2 NGC 6633

10x 50 From IC 4665 navigate 10° eastwards, where you will find NGC 6633. This lovely little cluster is often overlooked in lists of binocular objects because it can be tricky to find, but it is easily visible in a pair of 10x50s, the four brightest stars shining against the 20-arcminute elongated glow of unresolved fainter stars. Compare it to the Summer Beehive and you will see that its stars are yellower, and therefore older. It is an intermediate age cluster at just under 700 million years old. ☐ **SEEN IT**

3 GRAFF'S CLUSTER

10x 50 Pan 3° from NGC 6633, in the direction of mag. +4.6 Alya (Theta (θ) Serpentis), where you will find a misty patch just over 1° in diameter. This is Graff's Cluster, IC 4756, an enormous grouping of stars over 20 lightyears across and approximately 1,300 lightyears away. It richly rewards patience: try averted vision on it. As more detail comes into view, you may experience what others have described as being "brighter stars, scattered over a background of diamond dust". Its yellow stars suggest that it is a similar age to NGC 6633. ☐ **SEEN IT**

4 BARNARD 138

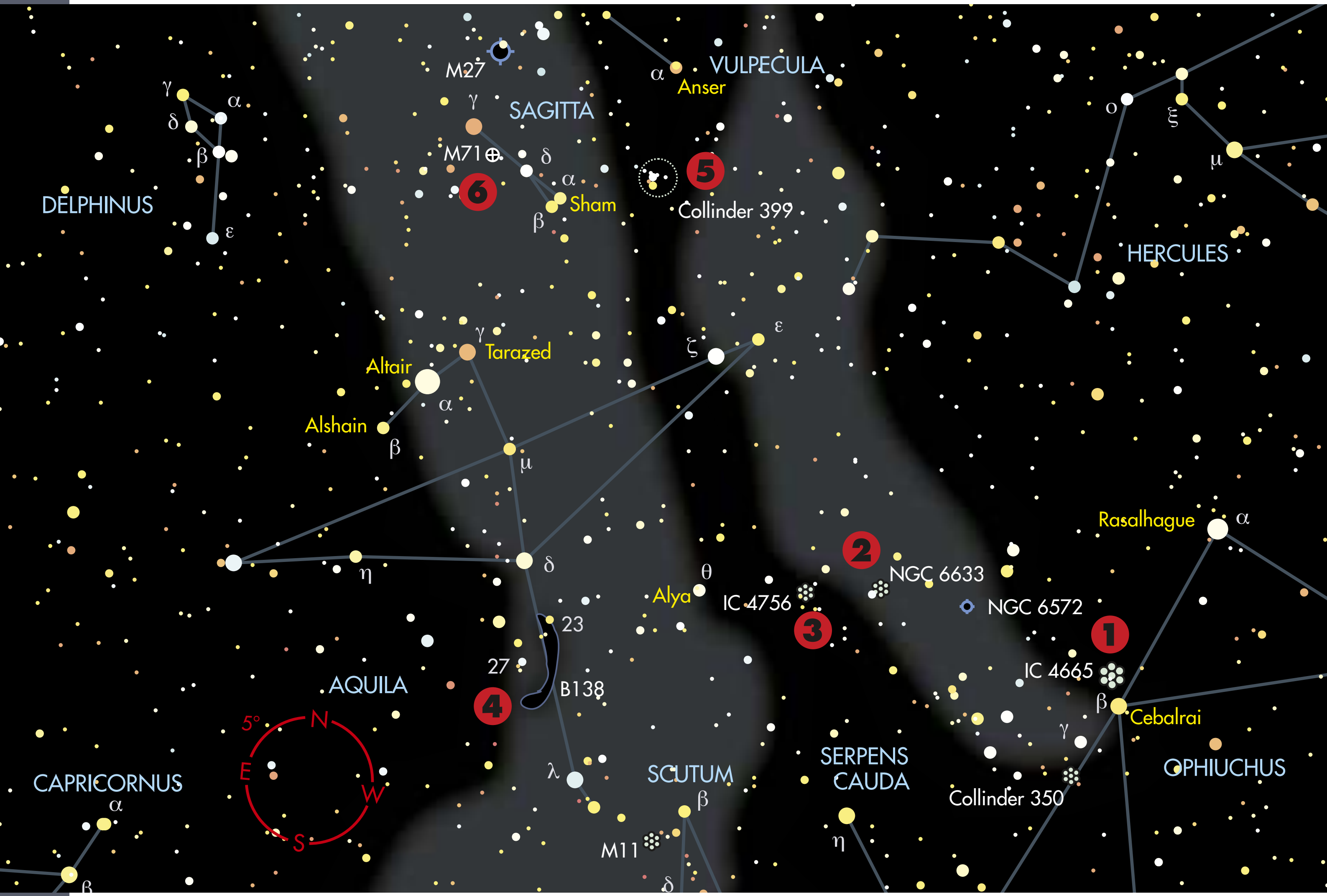
10x 50 You will need a transparent dark sky for our next object, Barnard 138, or Barnard's Black Lizard. Identify mag. +3.4 Delta (δ) Aquilae and navigate 2.5° southwest to mag. +5.2 23 Aquilae. Let your eyes to settle and you should see that this star is in a narrow dark band that runs northeast-southwest before curving east and passing 1° west of 27 Aquilae. The eastern edge is quite distinct, but the transition to the Milky Way background is more diffuse to the west. ☐ **SEEN IT**

5 THE COATHANGER

10x 50 We now head north to a popular star-party piece, an asterism variously designated Collinder 399, Brocchi's Cluster and Al-Sufi's Cluster. Find it 5° south of mag. +4.4 Anser (Alpha (α) Vulpeculae) or 4° northwest of mag. +4.4 Sham (Alpha (α) Sagittae). Even small binoculars will reveal the 10 brightest stars that give this asterism its common name. It spans 1.5°, which means that it will stay within the field of view long enough for several consecutive star-party observers to see it in mounted binoculars. It was first recorded by the 10th Century Persian astronomer Abd al-Rahman al-Sufi. ☐ **SEEN IT**

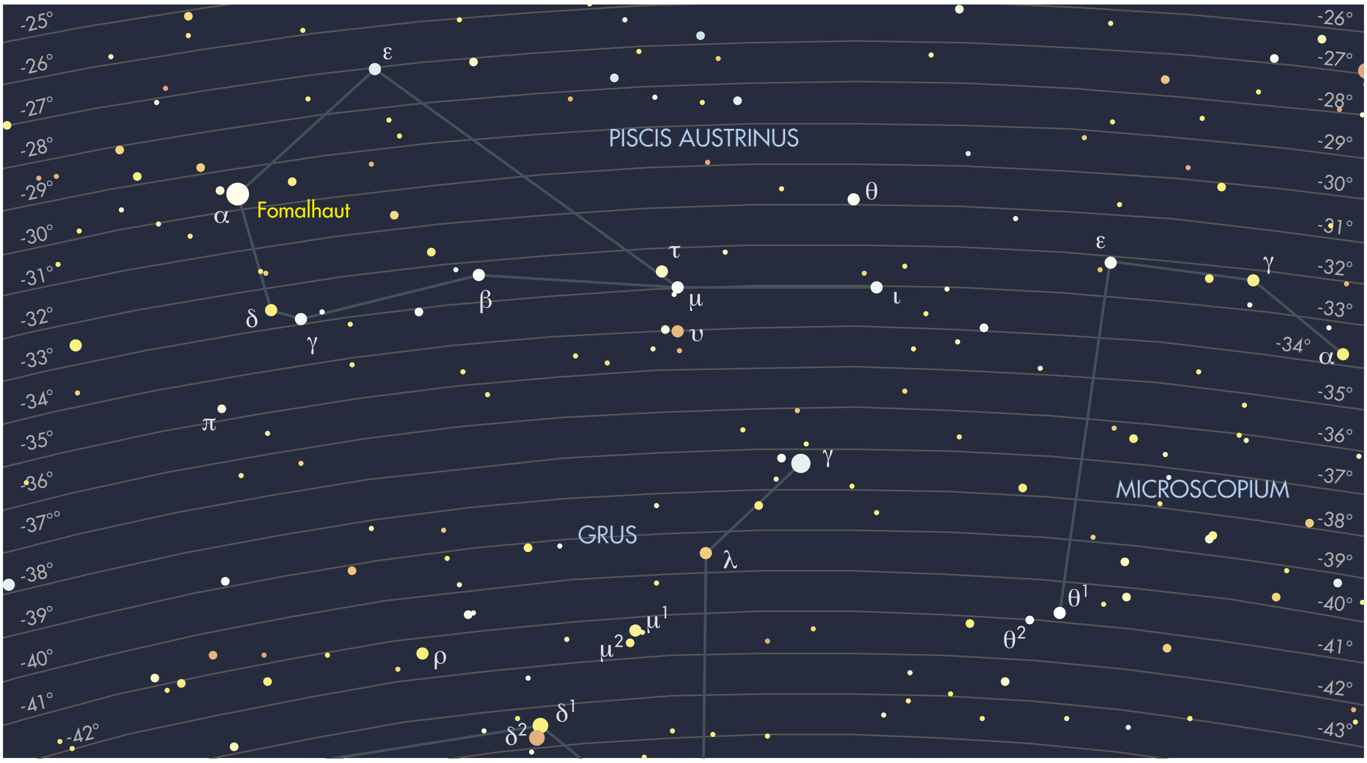
6 M71

15x 70 Is M71 a tight open cluster or a loose globular? After decades of dispute, the consensus is that it is the latter. You can find this enigmatic object just south of the mid-point of a line joining mag. +4.3 Delta (δ) and mag. +3.5 Gamma (γ) Sagittae. M71 is quite faint at mag. +8.2, but 15x magnification should at least reveal that it is not a star and averted vision will confirm this. The cluster spans 27 lightyears and is 12,000 light years away from us. It's about nine billion years old. ☐ **SEEN IT**



THE SKY GUIDE **CHALLENGE**

The most southerly star you can detect from your regular observing site



▲ **Fomalhaut is south at 01:20 BST (00:20 UT) on the 1st and four minutes earlier each following day. Gamma Gruis is south an hour before it**

Our minds tend to compartmentalise the sky into regions that are easy to view and those which are harder to examine. One common example of the latter is the murky part of the sky very close to the horizon, where the stars appear dimmer and less easy to identify.

This month, our challenge asks how far south you can actually see. In theory this should be easy to answer so long as you know your latitude. In the northern hemisphere, subtract 90 from your latitude to give the lowest theoretical declination visible due south. For example, from 53°N , the lowest theoretical declination should be 37°S (53 – 90 = –37). Of course, it's never that straightforward.

The first issue is to identify a bright star exactly on your declination limit. You also need to consider how close to your limit you can go. For example, given a perfect horizon a star on your limit should only appear for an instant when due south. However, this threshold is somewhat relaxed by atmospheric refraction.

The atmosphere refracts (bends) light. The closer to the horizon you're trying to see, the more refraction occurs, allowing us to see a little farther south than maths predicts. Refraction also varies according to atmospheric conditions, so the limit is not a constant.

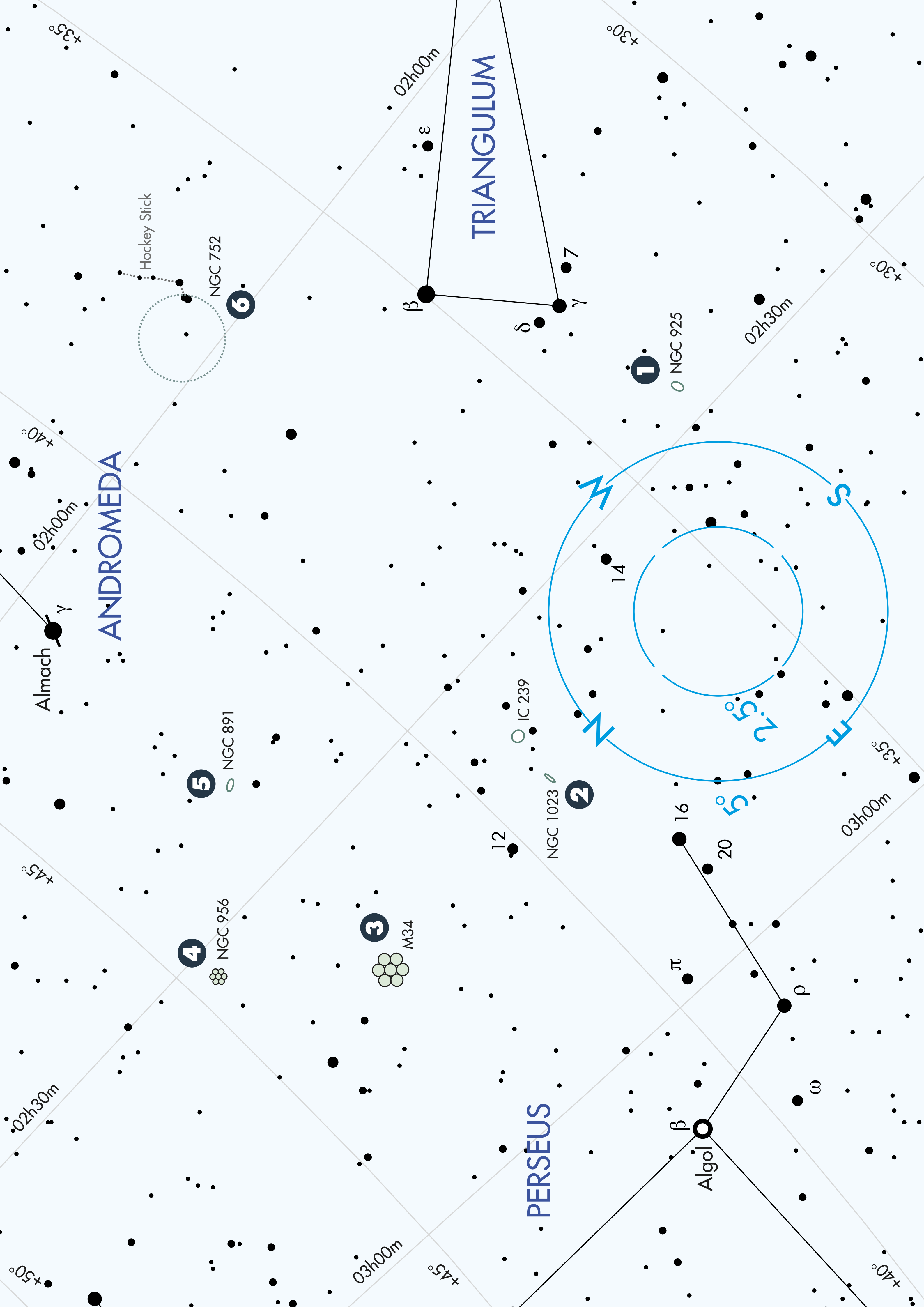
If your view to the south is built-up and obscured, you'll have a false elevated horizon and your limit will be further north. A flat seaward southern horizon is about as close to perfect as you can get, but if you live at altitude, an elevated view to the south should give you an additional advantage.

A good starting point is Fomalhaut (Alpha (α) Piscis Austrinii), the most southerly first-magnitude star. Shining at mag. +1.2 and located at a declination of –29.5°, Fomalhaut should be a relatively straightforward spot. Once you've found it, its host constellation of Pisces Austrinus, the Southern Fish, can be used to push your southern limits. Mag. +4.2 Delta (δ) Piscis Austrinii is 3° south-southwest of Fomalhaut at a declination of –32.5° and is dimmer, so it will be harder to find. South of the Fish's tail is mag. +3.0 Gamma (γ) Gruis, in the constellation of Grus, which has a declination of –37° 17', a much trickier prospect still.

Identify a number of stars around your theoretical limit throughout the year and keep a log of your attempts. Different results can be achieved using binoculars and telescopes. A camera on a fixed tripod pointing south can also be a great help. Capturing an exposure between one and five minutes long should produce a star-trailed image, which may make finding your elusive southern declination limit that much easier.

Gamma Gruis, just visible above a low cloud bank from 50.75°N

PETE LAWRENCE X 3


TRIANGULUM
ANDROMEDA
PERSEUS
Hockey Stick
6 NGC 752
1 NGC 925
2 NGC 1023
IC 239
5 NGC 891
4 NGC 956
3 M34
Almach
Algol
β
γ
δ
ε
7
γ
β
π
ρ
ω
12
14
16
20
N
E
S
W
2.5°
5°
02h00m
02h30m
03h00m
+30°
+35°
+40°
+45°
+50°

DEEP-SKY TOUR

This month we explore the borders of Triangulum, Perseus and Andromeda

☑ Tick the box when you've seen each one

1 NGC 925

The first stop on this month's tour is NGC 925 in Triangulum, which can be found by extending a line east of mag. +4.0 Gamma (γ) Trianguli for 2° – the same apparent distance between Gamma Trianguli and nearby mag. +3.0 Beta (β) Trianguli. NGC 925 is an 11th-magnitude, almost face-on spiral galaxy. Visually it appears to be 6x4 arcminutes in size, although in reality it extends to 11.2x6.3 arcminutes. NGC 925's surface brightness is low and a 8-inch or larger scope is required to show a faint elongation in an east-southeast to west-northwest direction. Low powers or small apertures may hint at a north-south elongation caused by nearby foreground stars, the brightest of which is around mag. +10.0. ☐ **SEEN IT**

2 NGC 1023

Imagine a line from Beta to Gamma Trianguli. Turn 90° at Gamma and head northeast for three times the Beta-Gamma distance. A 6th-magnitude star sits just southeast of this position. Forty arcminutes further northeast is NGC 1023, a mag. +10.2 barred spiral galaxy, 7.9x3.5 arcminutes across. A 10-inch scope will reveal its barred core as a thin, bright needle of light measuring 3x1 arcminutes, while averted vision will let you see a fainter outer envelope. Larger apertures may provide a glimpse of galaxy NGC 1023A towards the eastern end of the faint haze, a tricky 14th-magnitude target that's 1.3x0.7 arcminutes across. NGC 1023 is the brightest member of the NGC 1023 Group, all of which are located 20.6 million lightyears away. ☐ **SEEN IT**

3 M34

A little over 3.5° north of NGC 1023 is mag. +5.2 open cluster M34. With a 35-arcminute diameter, this object is well suited to small instruments using low power eyepieces. A 6-inch scope reveals a concentration of around 50 stars brighter than 11th-magnitude, with the total star count believed to be approaching 400 stars. The cluster is located an estimated 1,500 lightyears from Earth and thought to be around 200-250 million years old. Look out for a close pair of mag. +8.4 and +9.1 stars, 1.4 arcseconds apart, on the southern edge of the cluster. You can also navigate to M34 by looking 5° west-northwest of Algol (Beta (β) Persei). ☐ **SEEN IT**

4 NGC 956

We hop across the border into Andromeda for our next target, the open cluster NGC 956. It can be found 2.5° northwest of M34. At mag. +8.9 and a diameter of 7 arcminutes it is completely outshone by M34 in all senses of the word. A small telescope shows a subtle concentration of around 10 stars, best seen with a low power. With a bit of imagination, the brightest stars appear to form an S shape. Sadly, if you do manage to identify NGC 956, the bad news is that although it is listed as an open cluster, it is now known to be nothing more than a chance alignment of stars! ☐ **SEEN IT**

THIS DEEP-SKY TOUR HAS BEEN AUTOMATED

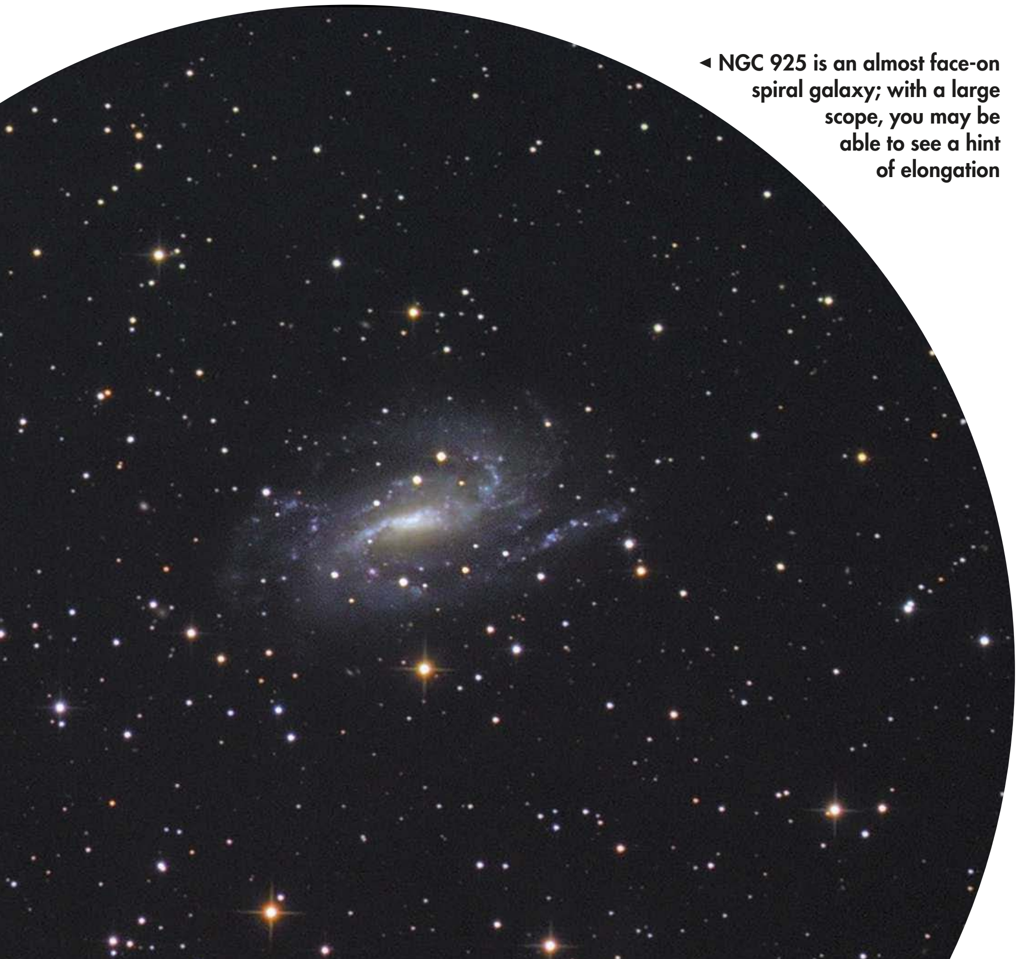
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

5 NGC 891

After the let-down of non-cluster NGC 956 you'll be pleased to know that our next target is more impressive. The edge-on spiral galaxy NGC 891 is within the borders of Andromeda, midway between M34 and the beautiful mag. +2.2 binary star Almach (Gamma (γ) Andromedae). The galaxy has a visual magnitude of +10.8 and is visible in a 10-inch scope as a faint needle of light that's 10x1 arcminutes in size. A 12-inch instrument doubles its thickness and hints at a faint dust lane passing across the 4x2-arcminute core. This galaxy is 27.3 million lightyears away and is often described in terms of how similar it looks to our own galaxy, having a similar luminosity and size. ☐ **SEEN IT**

6 NGC 752

Mag. +5.7 open cluster NGC 752 is 3.5° northwest of Beta Trianguli. A 6-inch scope using a low power will reveal around 75 stars within its 45-arcminute diameter; 60 of these cluster stars are brighter than 9th-magnitude. A bright, yellow-red pair of mag. +5.9 and +5.7 stars are prominent on the south-southwest edge. Many 'star-strings' are visible, including a pretty 10th-magnitude quartet aligned southwest of the core. Another fainter line pours south out of the core towards the southeast. Brighter stars to the west of NGC 752 form a hockey stick shape, with the yellow-red pair mentioned earlier marking the bottom. In this context, NGC 752 would be the ball about to be hit. ☐ **SEEN IT**



◂ **NGC 925 is an almost face-on spiral galaxy; with a large scope, you may be able to see a hint of elongation**

YOUR BONUS CONTENT

Print out this chart and take an automated Go-To tour

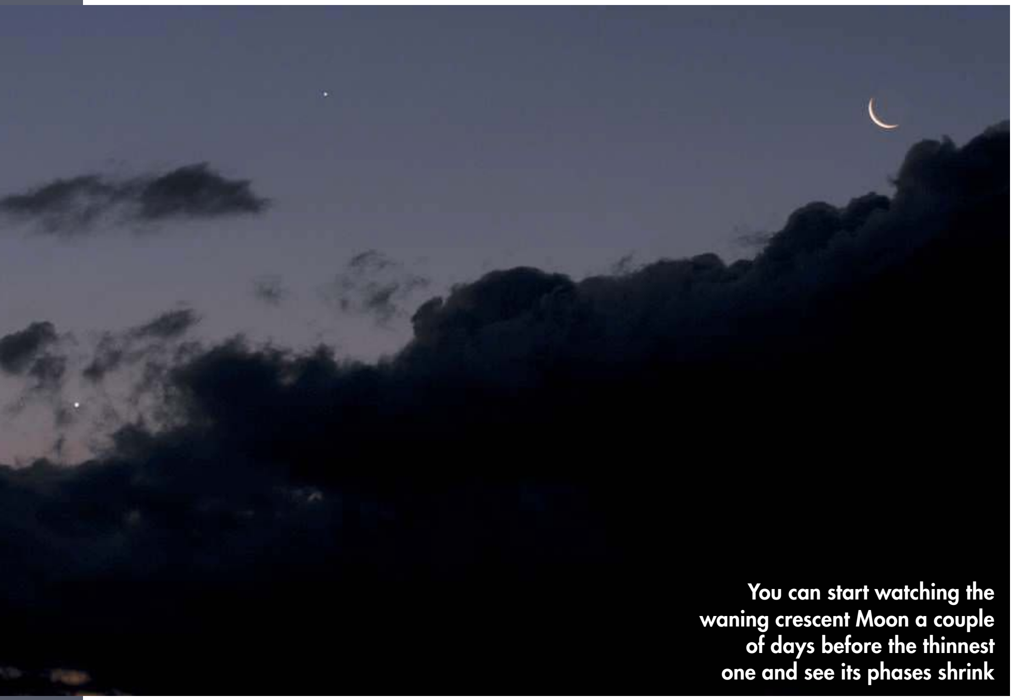
CHART: PETE LAWRENCE, PHOTO: GÜNTER KERSCHHUBER/CCDGUIDE.COM

ASTROPHOTOGRAPHY

The thinnest of lunar crescents

RECOMMENDED EQUIPMENT

DSLR with shutter release cable, telescope or lens, tripod or tracking mount recommended for longer focal lengths



You can start watching the waning crescent Moon a couple of days before the thinnest one and see its phases shrink

ALL PIUCTURES: PETE LAWRENCE

Photographing the thin crescent Moon is both challenging and great fun. There are two opportunities in any given month, one for the waxing crescent in the evening twilight sky and one for the waning crescent in the morning. Not all occurrences are favourable, however. During the spring months, it's the waxing crescent Moon that's best placed, the waning one tending to be too close to the horizon as the Sun rises. During autumn the tables turn and it's the waning crescents that are easier to see.

In many ways hunting the waning crescent is more useful than its waxing counterpart, the reason being that spotting a thin waning crescent provides training to spot and even thinner one the next morning. With waxing crescents the thinnest event happens first. Miss it and the next night it becomes a little easier. This month there is a golden opportunity to catch a 1.3%-lit waning crescent Moon on 19 September.

Start two days before, on the morning of the 17th. Aim to make your attempt 50 minutes before the Sun pops up above the horizon. From the centre of the UK, this means a 06:00 BST (05:00 UT) start. The 11.1% lit waning crescent Moon will be 10° above and right of brilliant planet Venus, over in the east. Mars and Mercury are there too, a similar distance from Venus in the opposite direction to the Moon. These planets will be in close proximity to one another this morning and a lovely sight to photograph in their own right. Compare their separation to the diameter of the Moon: on the 17th they will be two-thirds the Moon's apparent diameter apart.

This Moon is a relatively easy target to photograph. Take your time, focus as accurately as possible and take your shot. As indicated in our step-by-step guide, make sure you don't overexpose the lunar surface to white. Just below white at the brightest points is fine. Make a note of your settings and take in that beautiful view. This is an excellent training session for tomorrow's Moon.

On the morning of 18 September, at the same time you ventured out on the 17th, things will have changed. The Moon's crescent will now be noticeably thinner at 4% lit. The Moon's position will also have changed so that it now sits between Venus and the Mercury-Mars pair. Mag. +1.4 Regulus (Alpha (α) Leonis) is also visible 0.25° north of the Moon's northern limb. Despite being thinner, this Moon shouldn't give too many problems for photography. It'll still have a decent altitude in reasonably dark twilight and should be relatively easy to frame and focus.

On 19 September, big changes will be apparent. Mercury and Mars will now appear separated by four times the Moon's apparent diameter. The Moon's crescent will now be only 1.3% lit and it will lie below and left of Mercury. Use the Mars-Mercury line to locate it, extending that line by roughly twice the distance again, down towards the horizon.

By carefully noting the settings you used on previous mornings it should be possible to achieve a convincing shot of this thin waning crescent Moon. If the weather holds, and you do manage to grab a shot of it, as well as having a trophy of the Solar System to keep, you'll feel a definite sense of achievement. Good luck!

KEY TECHNIQUE

SWIFT SETTING CHANGES

Imaging a thin waxing or waning crescent Moon is challenging. Appearing against a bright twilight, the delicate crescent is easily lost both to the eye and to the camera. Choosing the right settings here is essential as is keeping a constant eye on the camera's preview screen. Adjusting settings on the fly is a key skill that astrophotographers have to master and here the technique is pushed to the limit. With mastery over the settings it's often possible to use the camera in thin Moon situations to record the crescent even when it's not visible to the naked eye.

✉ **Send your image to: hotshots@skyatnightmagazine.com**

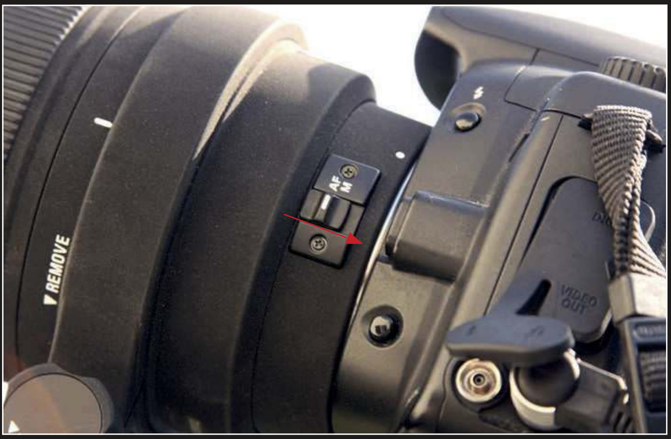
STEP BY STEP

STEP 1

Decide what sort of capture you're after. A general wide shot is easier than a close-up of the Moon's crescent, but the shape and appearance of the crescent will be hard to pick out with really short focal lengths. Try a focal length between 100mm and 1,000mm. Connecting a camera to a telescope is a great way to achieve a larger image scale.

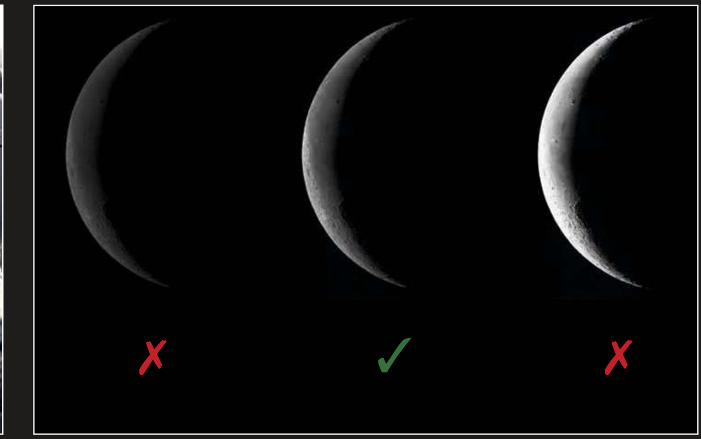
STEP 2

Pick a location that gives an unobstructed view towards the east that's free of bright lights. If you have to travel to achieve this, make sure you arrive in good time to set up properly. If you're using an equatorial mount, a rough align with Polaris should be fine. If Polaris is hidden, a compass is a good way to get an approximate alignment north.



STEP 3

Set your camera lens to manual focus, then focus on a bright star or planet. Use Live View if available. If using a standard lens, open the lens fully (set it to the lowest f/number) then close it by a couple of stops. This avoids distortion which may occur with some lenses when fully open. Set the camera to manual operation.

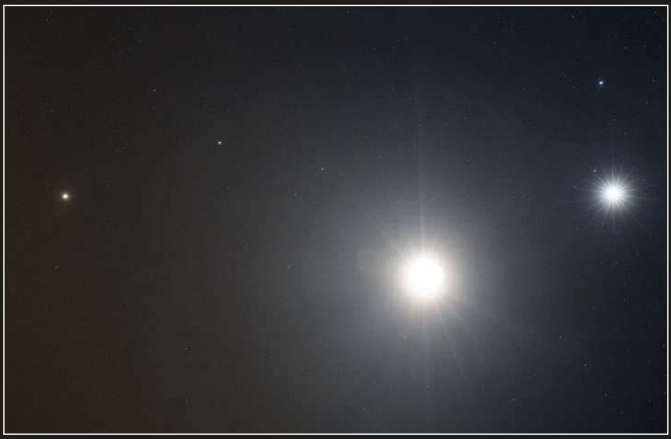


STEP 4

A low ISO (100-400) can be used if a tracking mount is being used. A fixed tripod necessitates a higher ISO and shorter exposures to avoid motion blur. For longer focal lengths, adjust the exposure to achieve a bright image avoiding pure white. For wide-field shots, overexposing the crescent often reveals earthshine.

STEP 5

Use a remote shutter release cable to avoid camera shake. Bracketing exposures is also good practice. For example, if you think that a six-second shot is best, take one followed by four more lasting five, four, seven and eight seconds. Shoot in RAW+JPG. The RAW files give the cleanest results while the JPG ones offer quick editing.



STEP 6

If you're using a wide-field setup to capture nearby planets as well, a dramatic diffraction burst effect can be achieved by stopping a standard lens down (increasing the f/number) to around f/16 or f/22. Here you'll need to raise the ISO, or with a tracking mount extend the exposure. Take the shot, examine and adjust to suit your taste.

Stay on track during observations

NEW

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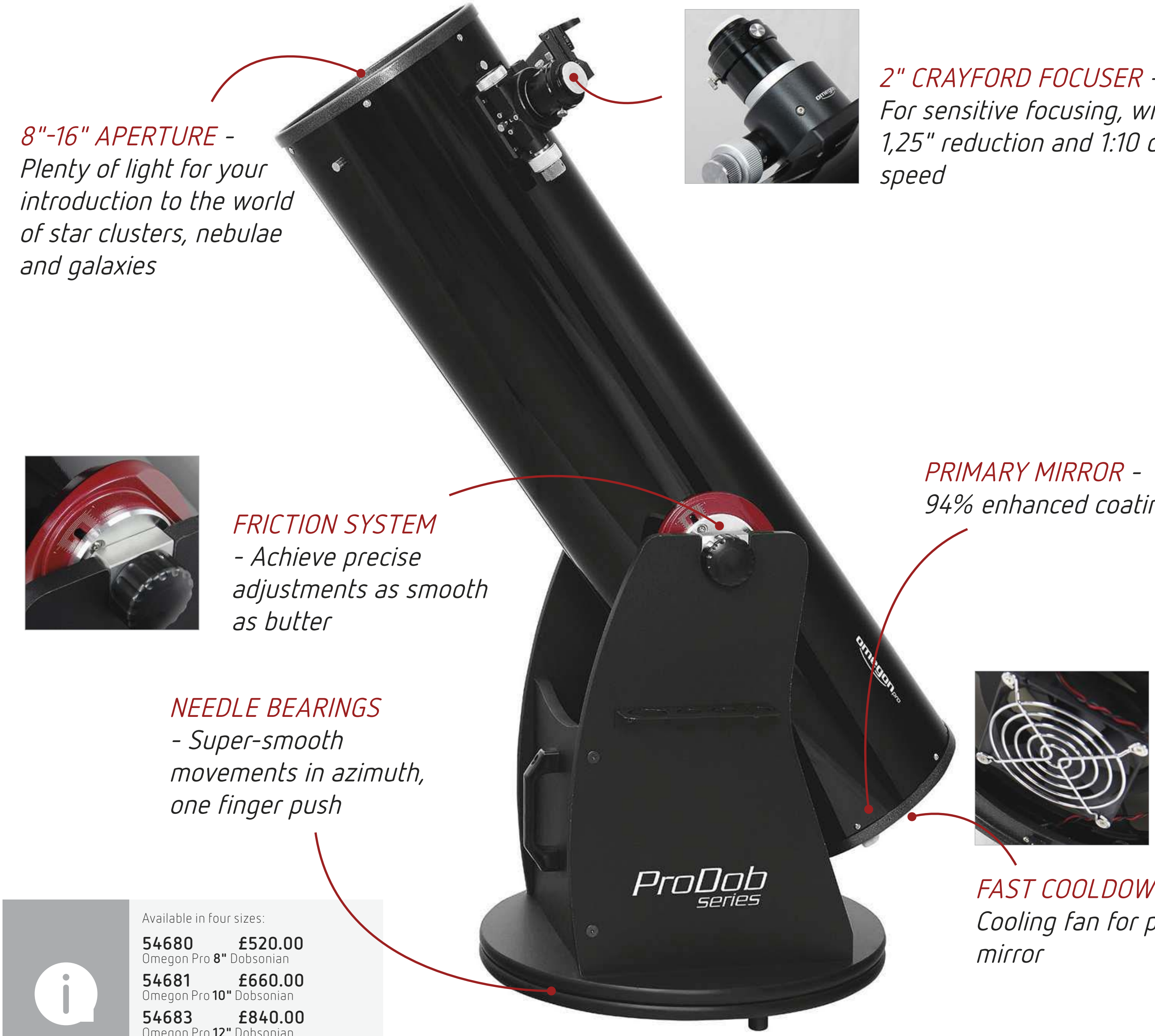

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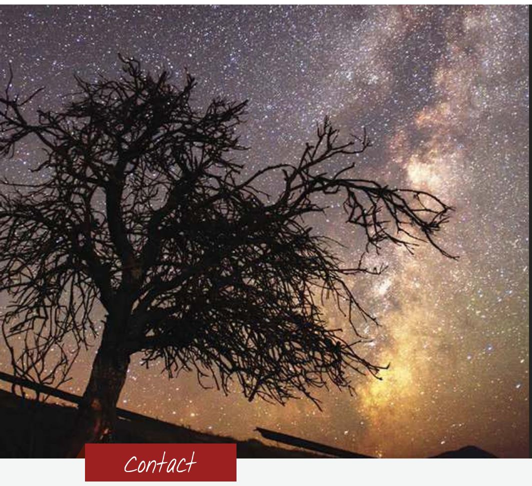

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The Voyagers delivered revelatory findings at their very first destination, the gas giant Jupiter. More surprises would follow

BBC WORLD SERVICE

Astronaut Ron Garan talks to the scientists behind the Voyager mission in *The Weekend Documentary: Space 1977,* on the BBC World Service at 2pm on 20 August

VOYAGER

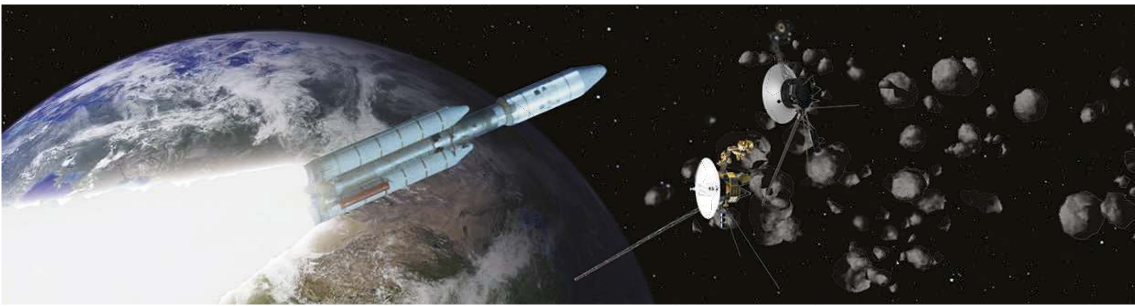
THE 40-YEAR SPACE JOURNEY

In 1977, two spacecraft left Earth to explore the gas and ice giants. On the anniversary of their departure, **Jenny Winder** charts their journey towards the edge of the Solar System

NASA/JPL-CALTECH X 5/PROCESSING BY STEVE MARSH, MARK GARLICK

Voyager mission timeline

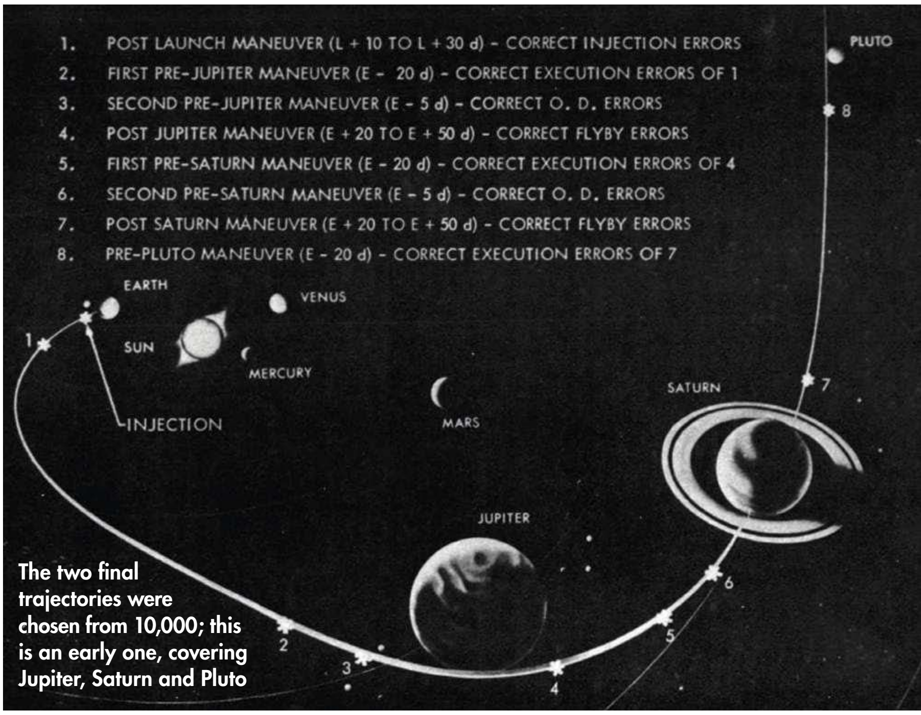
On their long travels, the Voyagers visited four planets and imaged 48 moons. Now they are at the very edge of the Solar System



20 AUGUST 1977
Voyager 2 launches from Cape Canaveral at 14:29 UT atop a Titan IIIE-Centaur launch vehicle

5 SEPTEMBER 1977
Voyager 1 launches at 12:56 UT from Cape Canaveral also atop a Titan IIIE-Centaur

10 DECEMBER 1977
Voyager 2 enters the asteroid belt, swiftly followed by Voyager 1


1. POST LAUNCH MANEUVER (L + 10 TO L + 30 d) - CORRECT INJECTION ERRORS
2. FIRST PRE-JUPITER MANEUVER (E - 20 d) - CORRECT EXECUTION ERRORS OF 1
3. SECOND PRE-JUPITER MANEUVER (E - 5 d) - CORRECT O. D. ERRORS
4. POST JUPITER MANEUVER (E + 20 TO E + 50 d) - CORRECT FLYBY ERRORS
5. FIRST PRE-SATURN MANEUVER (E - 20 d) - CORRECT EXECUTION ERRORS OF 4
6. SECOND PRE-SATURN MANEUVER (E - 5 d) - CORRECT O. D. ERRORS
7. POST SATURN MANEUVER (E + 20 TO E + 50 d) - CORRECT FLYBY ERRORS
8. PRE-PLUTO MANEUVER (E - 20 d) - CORRECT EXECUTION ERRORS OF 7
PLUTO
EARTH
VENUS
SUN
MERCURY
INJECTION
MARS
SATURN
JUPITER
1
2
3
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5
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7
8

The two final trajectories were chosen from 10,000; this is an early one, covering Jupiter, Saturn and Pluto

Forty years ago, in August and September 1977, NASA launched two spacecraft on an audacious mission that would eventually study all four giant outer planets and 48 of their moons, and go on to explore the outer reaches of our Solar System. Today, Voyager 1 is our most distant spacecraft, and in 2012 became the first to enter interstellar space. Voyager 2 isn't far behind; it's hoped that it too will 'go interstellar' in the next five years.

The origins of the mission hark back to 1965, when it was realised that a planetary alignment in the latter half of the 1970s would enable a spacecraft to make a complete survey of Jupiter, Saturn, Uranus, Neptune and Pluto. Such an alignment only occurs every 175 years – it was an opportunity not to be missed.

To make the most of it, NASA settled on two identical spacecraft to travel on two separate trajectories. Both would study Jupiter and Saturn. Voyager 1 would then go on to fly by Saturn's largest moon Titan. Voyager 2, meanwhile, would have the option to go to Uranus and Neptune, becoming the first spacecraft to visit either. Each planetary flyby would alter the spacecraft's flight path to deliver it onto the next planet and increase its velocity, reducing the flight time to Neptune from 30 years to just 12. Pluto was off the table; the choice was between it and Titan, and Titan was seen as a more interesting target.

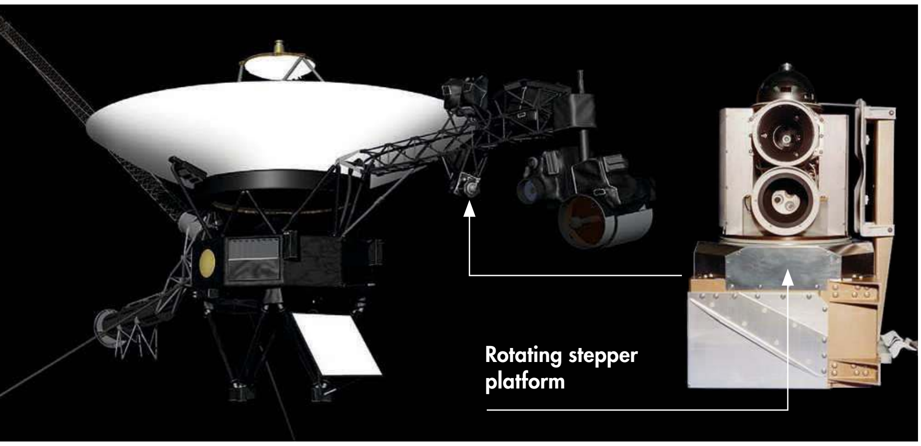
Budget constraints meant the spacecraft were officially only built to last five years, with the hope that they would be able to complete the extended mission to Uranus and Neptune. They launched with 11 scientific instruments: four on Voyager 1 continue to send back data about its surroundings, while five remain operational on Voyager 2.

One of the instruments still active on both is the low-energy charged particle detector (LECP) instrument, which scans the sky through 360° every few tens of seconds measuring cosmic rays. That it continues to function is extraordinary, says its principal investigator, Dr Stamatios M Krimigis.

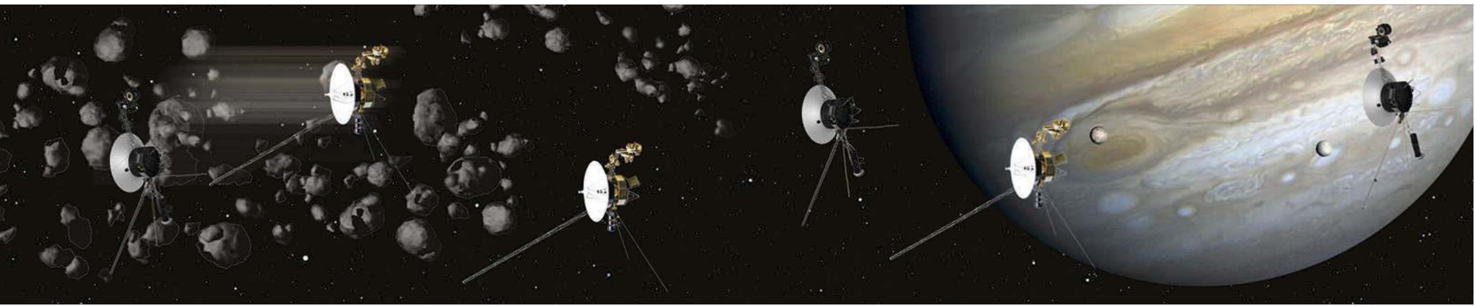
"The most remarkable design feature of LECP was the stepper motor," he says. "A mechanical device like this in space was frowned upon because everyone thought it could get stuck in short order. We tested the motor for about 500,000 steps, twice the expected usage and it survived. Now it's performed over seven million steps and counting."

Science data from the instruments is returned to Earth in real time via each probe's high-gain antenna. The signals are picked up by the Deep Space Network (DSN), a global spacecraft tracking

▼ The Voyager LECP instrument; like all others that remain operational, it has long surpassed its expected working life



NASA/JPL-CALTECH X 8, NASA/JPL-CALTECH/JHUAPL, MARK GARLICK



19 DECEMBER 1977
Voyager 1 overtakes its twin, placing it on course to reach Jupiter first

8 SEPTEMBER 1978
Voyager 1 exits the asteroid belt and continues on to Jupiter

21 OCTOBER 1978
On a slower trajectory, Voyager 2 finally exits the asteroid belt

5 MARCH 1979
Voyager 1 makes its closest approach to Jupiter

9 JULY 1979
Voyager 2 makes its closest approach to Jupiter

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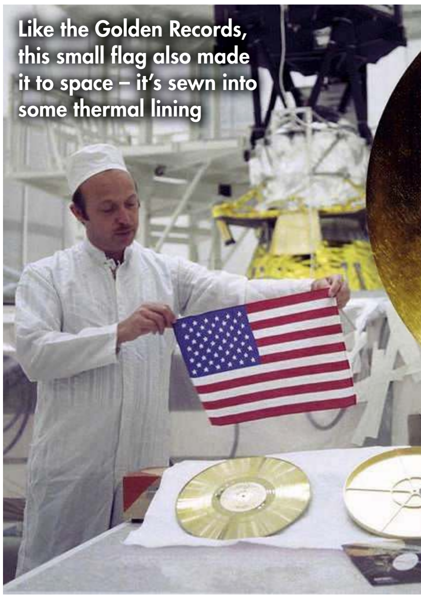
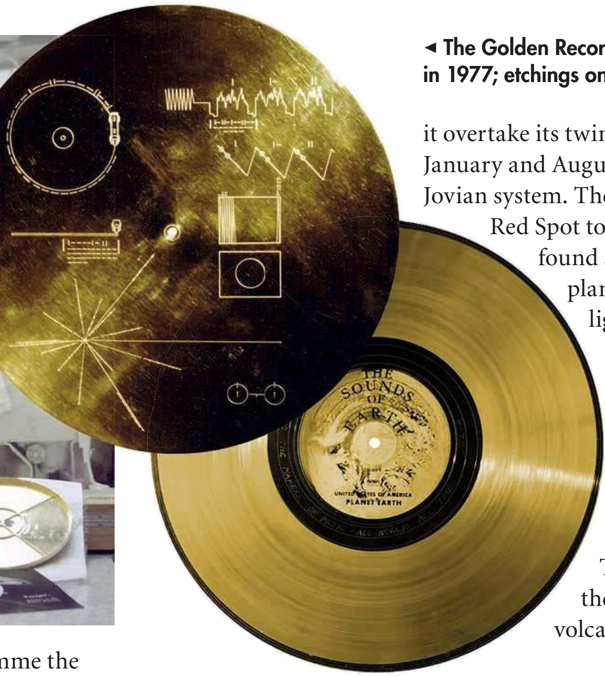


Like the Golden Records, this small flag also made it to space – it's sewn into some thermal lining



◂ The Golden Records are a snapshot of Earth as it was in 1977; etchings on the covers explain how to play them

system, which was also used to reprogramme the spacecraft remotely on more than one occasion. Travelling too far from the Sun for solar panels to be employed, the probes rely on three radioisotope thermoelectric generators for power. These convert heat produced from the radioactive decay of plutonium into electricity.

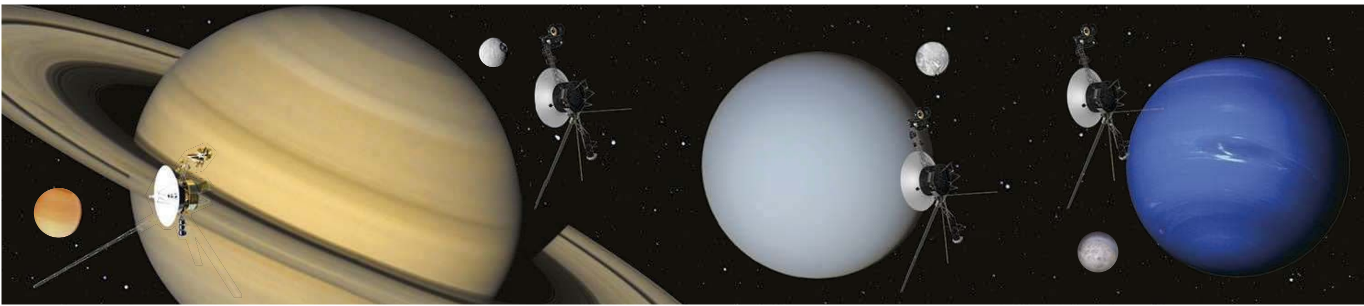
Messages for ET

Each spacecraft also carries a message from humanity in the form of a 12-inch gold-plated copper record. The cover for the Golden Records bear diagrams explaining how to play them, showing the location of our Sun and the two lowest states of the hydrogen atom as a fundamental clock reference.

The selection of content for the record, by a committee chaired by Carl Sagan, was completed in six weeks, chosen to portray the diversity of life and culture on Earth. There are spoken greetings in 55 languages; 116 images; recordings of natural sounds; music from Bach, a Navajo Indian song, Azerbaijani folk music and Chuck Berry; and even a recording of the brainwaves of Ann Druyan, the creative director of the project.

Voyager 1 was launched two weeks after Voyager 2, but on a shorter and faster trajectory that would see it overtake its twin and reach Jupiter first. Between January and August 1979, the Voyagers studied the Jovian system. They revealed Jupiter's famous Great Red Spot to be a complex anticyclonic storm, found smaller storms throughout the planet's clouds and saw flashes of lightning in the atmosphere on the night side. Jupiter's faint, dusty rings were also discovered, along with the satellites Adrastea, Metis and Thebe. But the highlight of the Jupiter mission was the discovery of active volcanism on the moon Io. Together, the Voyagers observed the eruption of no fewer than nine volcanoes on Io. "At that time, the ▸

Voyager 2 thunders into the sky on 20 August 1977. It launched two weeks ahead of Voyager 1, owing to its slower trajectory

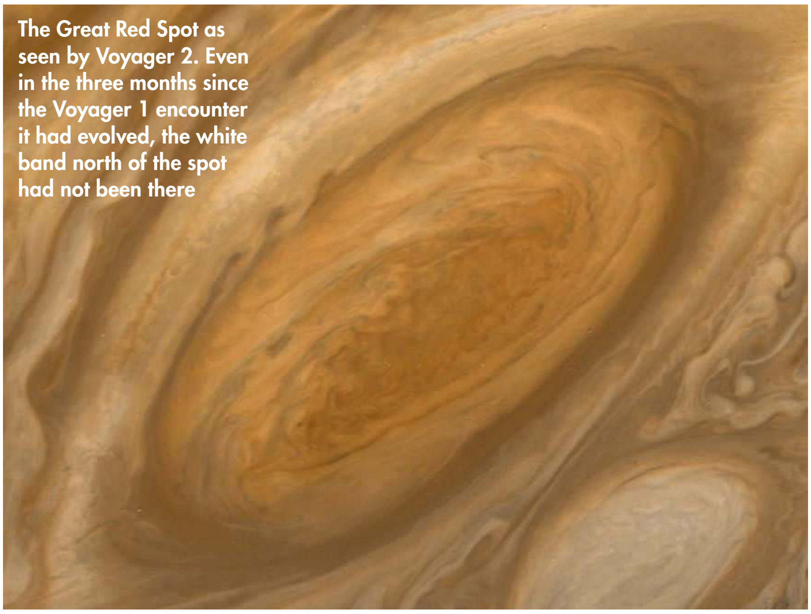


12 NOVEMBER 1980
Voyager 1 flies by Titan and Saturn, then begins its journey out of the Solar System

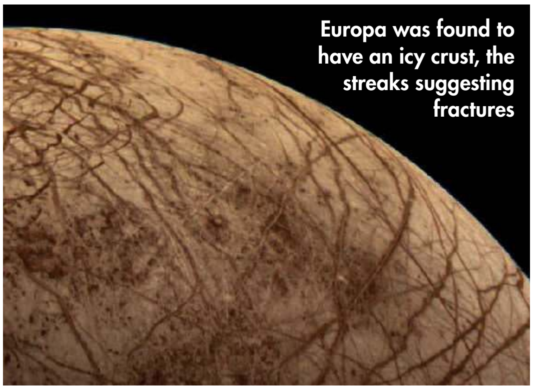
25 AUGUST 1981
Voyager 2 flies by Saturn but remains within the plane of the planets, bound for Uranus

24 JANUARY 1986
Voyager 2 has the first-ever encounter with Uranus, revealing a bland visible surface

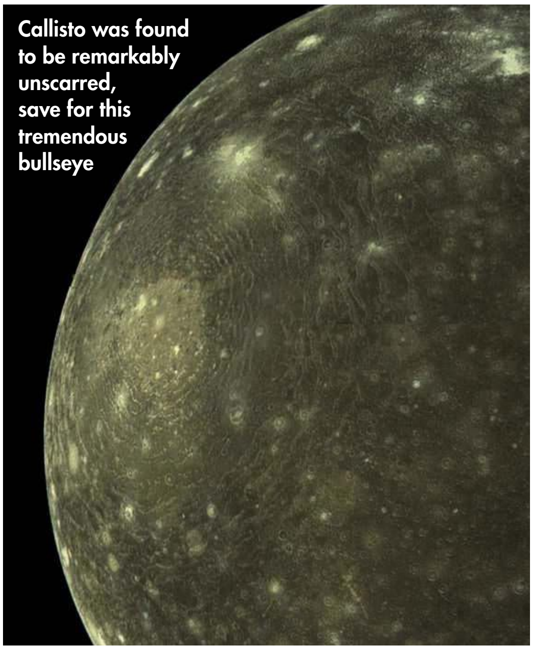
25 AUGUST 1989
Voyager 2 is the first probe to observe Neptune, a stormier planet than its neighbour



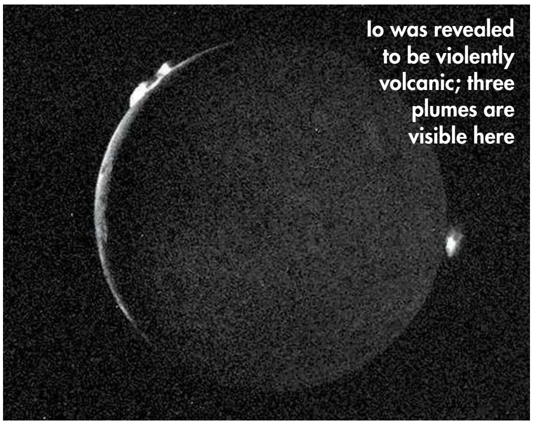
The Great Red Spot as seen by Voyager 2. Even in the three months since the Voyager 1 encounter it had evolved, the white band north of the spot had not been there



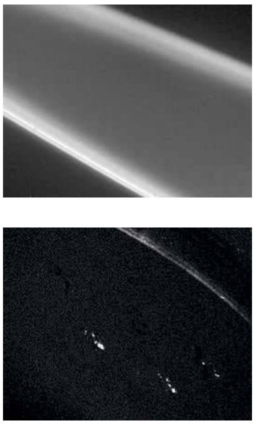
Europa was found to have an icy crust, the streaks suggesting fractures



Callisto was found to be remarkably unscarred, save for this tremendous bullseye



Io was revealed to be violently volcanic; three plumes are visible here



▲ Dust within Jupiter's newly discovered rings (top) and lightning on the night side of the planet (bottom)

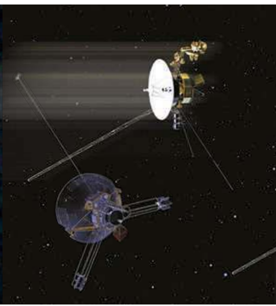
NASA/JPL-CALTECH X 22, MARK GARLICK

▸ only known active volcanoes in the Solar System were here on Earth, and here was a moon, just a moon of Jupiter, that had 10 times more volcanic activity than here on Earth," explains Voyager project scientist Ed Stone, who has been with the mission from the start. The Voyagers also found Io was shedding a thick torus of ionised sulphur and oxygen, and revealed evidence for an ocean beneath the icy crust of Jupiter's moon Europa.

At Saturn, they studied the planet's complex rings and its atmosphere, and found aurorae at polar latitudes and aurora-like emissions of ultraviolet hydrogen at mid latitudes. They measured Titan's mass, studied its thick nitrogen atmosphere and imaged 17 of Saturn's moons, including three new discoveries: Atlas, Prometheus and Pandora.

From there the two probes parted company as Voyager 1 began its long journey out of the Solar System. Voyager 2 headed to Uranus, where it discovered 11 new moons and visited 16.
It discovered the planet's magnetic field and studied the ring system. At Neptune Voyager 2 discovered

14 FEBRUARY 1990
Voyager 1 takes the Pale Blue Dot image of Earth from 6 billion km away

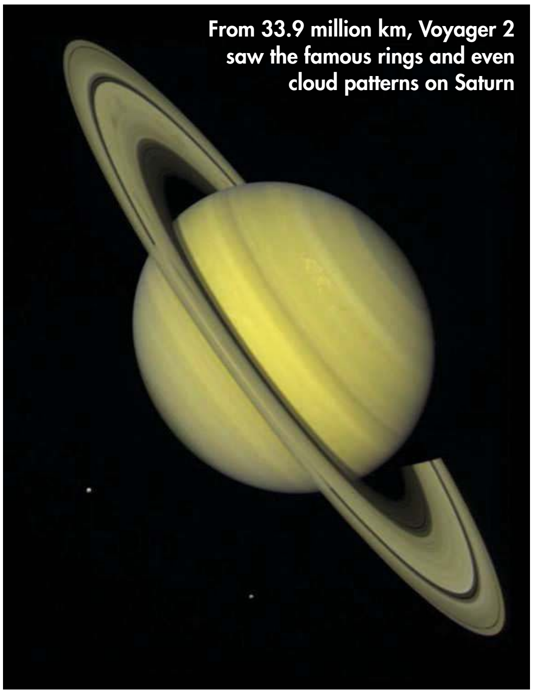


17 FEBRUARY 1998
Voyager 1 becomes the most distant human-made object in space

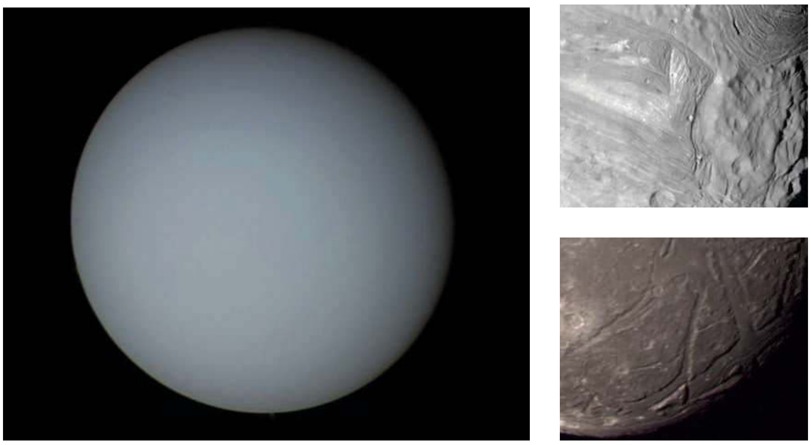
17 DECEMBER 2004
Voyager 1 passes the termination shock and enters the heliosheath

30 AUGUST 2007
Voyager 2 passes the termination shock and enters the heliosheath

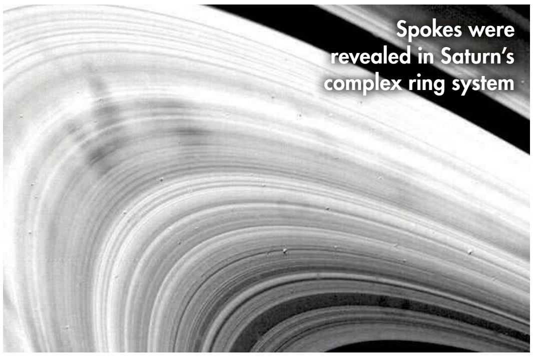
25 AUGUST 2012
Voyager 1 crosses the heliopause and enters interstellar space



From 33.9 million km, Voyager 2 saw the famous rings and even cloud patterns on Saturn

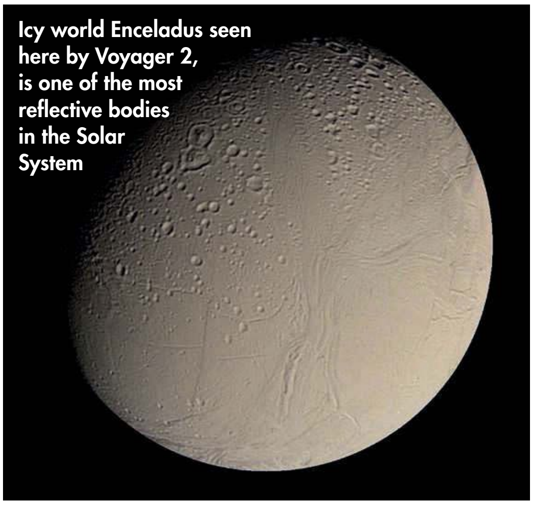


▲ Surprisingly, Uranus was seen to be featureless when Voyager 2 arrived (left) but moons like Ariel (above right) and Miranda (top right) revealed wild and varied surface features pointing to pasts marked by dramatic geological activity



Spokes were revealed in Saturn's complex ring system

▲ Titan's atmosphere is so thick that the Voyager could not see down to the surface (top) but pearly white Dione was seen glimmering in front of Saturn's clouds (bottom)



Icy world Enceladus seen here by Voyager 2, is one of the most reflective bodies in the Solar System

storms, including the Great Dark Spot, and 1,600km/h winds – the strongest on any planet. It imaged eight of Neptune's moons, discovering five of them and saw active geysers on the largest moon, Triton.

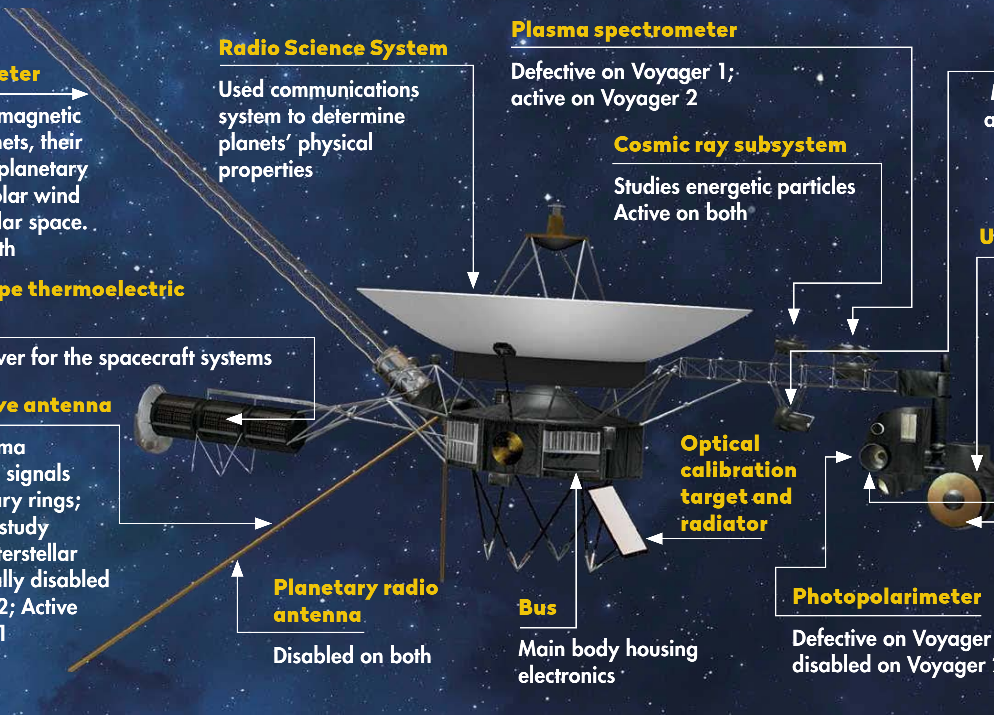
One last glimpse

On Valentine's Day 1990, Voyager 1 took the final pictures of the mission. Turning its camera back towards the Sun, from about 6 billion km away, it took images of Neptune, Uranus, Saturn, Jupiter, Venus and – suspended in a beam of sunlight – the now famous 'Pale Blue Dot' image of Earth. Carolyn Porco planned and executed this Family Portrait alongside Carl Sagan. "As soon as I joined the Voyager imaging team in fall 1983, the idea arose in my mind to take an image of the planets, but especially Earth, as they would be seen from far away, to force that 'reckoning' that comes from seeing our cosmic place as it really is ... alone and isolated," she says.

This marked the end of the Voyagers' planetary explorations – the Grand Tour, as it's known – and ▸

The spacecraft and its instruments

Each Voyager is the size of a small car, has a 3.7m high-gain antenna and launched with 11 scientific instruments



Magnetometer
Investigates magnetic fields of planets, their moons, interplanetary space, the solar wind and interstellar space. Active on both

Radioisotope thermoelectric generators
Supplies power for the spacecraft systems

Plasma wave antenna
Studied plasma (ionised gas) signals from planetary rings; continues to study plasma in interstellar space. Partially disabled on Voyager 2; Active on Voyager 1

Radio Science System
Used communications system to determine planets' physical properties

Planetary radio antenna
Disabled on both

Plasma spectrometer
Defective on Voyager 1; active on Voyager 2

Cosmic ray subsystem
Studies energetic particles Active on both

Bus
Main body housing electronics

Optical calibration target and radiator

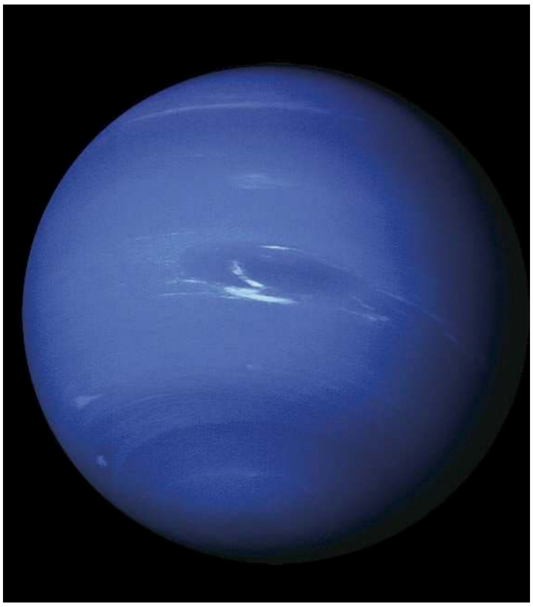
Photopolarimeter
Defective on Voyager 1; disabled on Voyager 2

Low-energy charged particle detector
Measures cosmic radiation, and analyses interplanetary energetic particles. Active on both

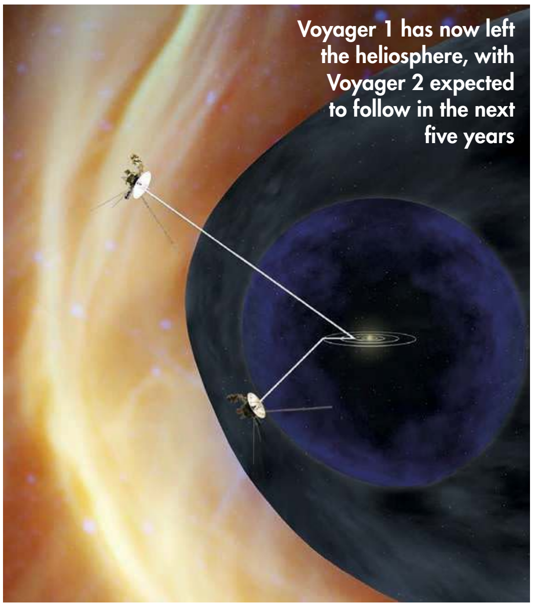
Ultraviolet spectrometer
Disabled on both.

Imaging science system
Narrow- and wide-angle camera system. Disabled on both

Infrared radiometer, interferometer and spectrometer
Disabled on both



◂▴ Neptune had a huge storm named the Great Dark Spot (left) while its moon Triton was found to have ice geysers (above)



Voyager 1 has now left the heliosphere, with Voyager 2 expected to follow in the next five years

NASA/JPL-CALTECH X 3, MARK GARLICK

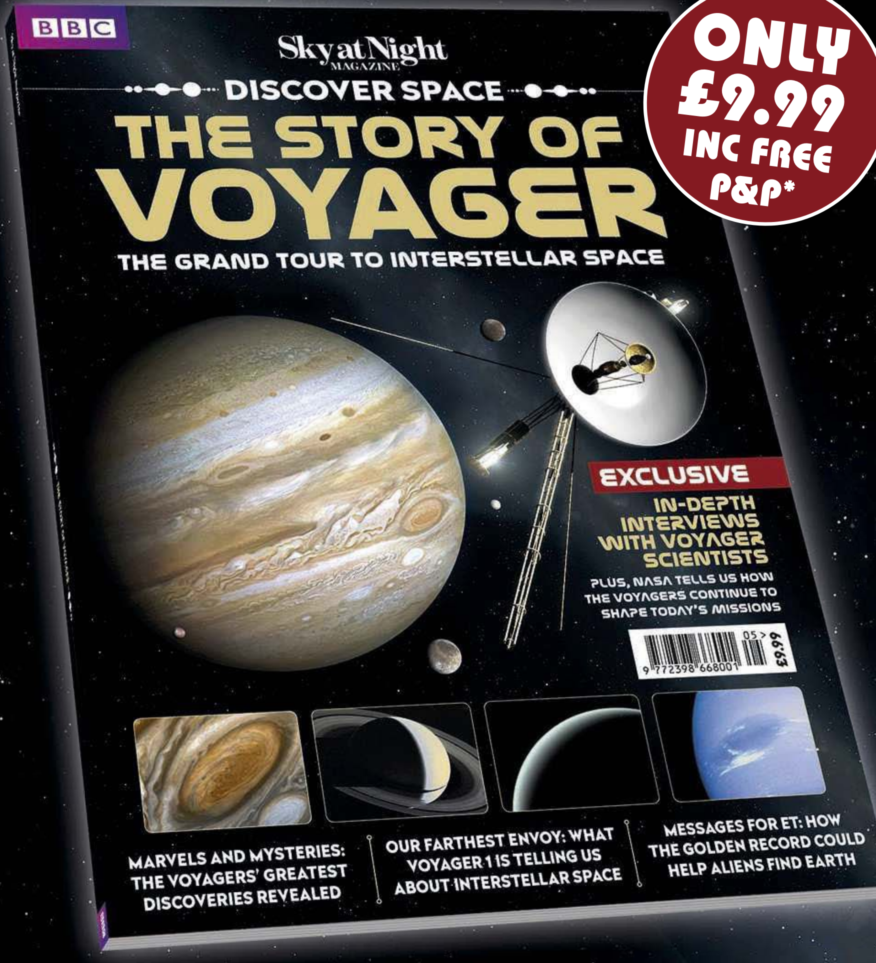
▸ the beginning of the Interstellar Mission. In 1998, Voyager 1 overtook Pioneer 10 to become the most distant spacecraft from the Sun. Voyager 2 is expected to pass Pioneer 10 by April 2019.

In December 2004, Voyager 1 crossed the termination shock, marked by a massive drop in particles detected from the Sun and a rise in cosmic ray particles. Voyager 2 followed in August 2007. Finally, on 25 August 2012, at 121 AU from the Sun, Voyager 1 officially crossed into interstellar space.

The Voyager team is still listening. "We listen every day, for four to eight hours per day, per spacecraft, and we'll continue to do that as long as they are sending us something new to learn," explains Ed Stone. From 2020, however, the remaining instruments will be switched off one by one to conserve power. It's hoped they will fly for at least 10 more years. "My goal is to have a 50th anniversary party for Voyager," says Suzanne Dodd, project manager of the Voyager Interstellar Mission.

Stone considers the Voyagers to be "our silent ambassadors". In 40,000 years, they will each pass 1.5 lightyears from stars in Andromeda and Camelopardalis. Having increased our knowledge of our solar neighbourhood, the Voyagers will take the story of Earth on to other star systems. Ⓢ

ABOUT THE WRITER
Jenny Winder is a science writer and broadcaster with a passion for astronomy outreach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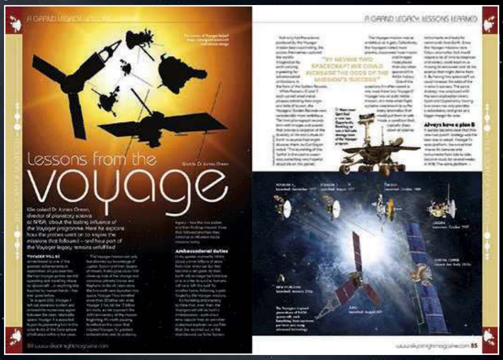

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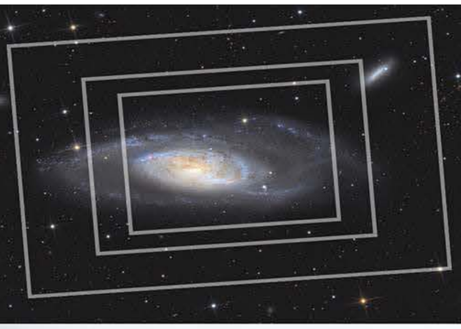

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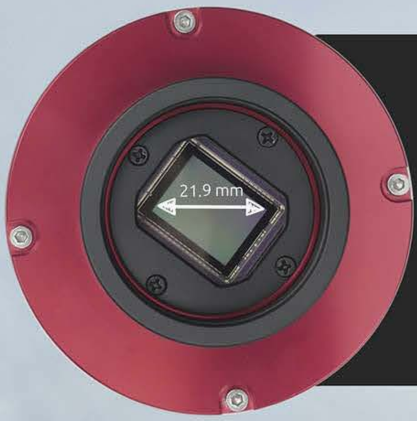

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QE peak: TBD
Full well: 20000e
ADC: 12bit

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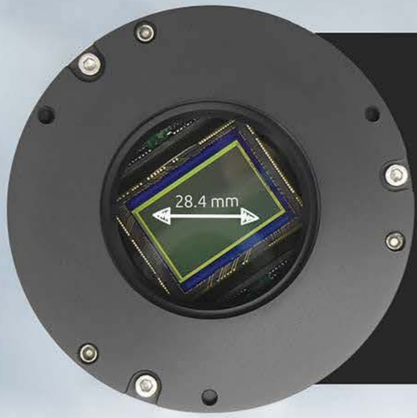

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Resolution: 16mp, 4944X3284px
Pixel Size: 4.78µm
Sensor size: 23.6 x 15.6mm
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QE peak: TBD
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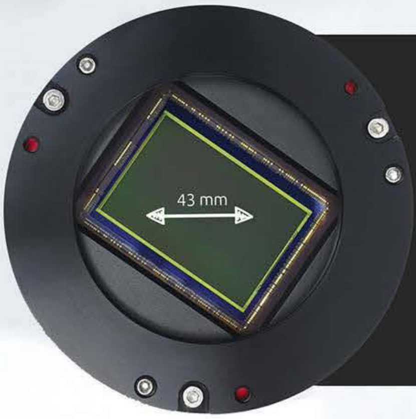
ASI094



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Pixel Size: 4.88µm
Sensor size: 36 x 24mm
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WHO HAS THE RIGHT STUFF?

A dozen people will be pushed to their limits to see if they could survive a space mission in new BBC Two show *Astronauts: Do You Have what It Takes?* **Elizabeth Pearson** investigates

These are the judges the contestants will have to impress: medical expert Kevin Fong, astronaut Chris Hadfield and psychologist Iya Whiteley

BBC/JAMES CHEADLE

The 12 contestants will be evaluated for their fitness, skills and quick thinking

Being an astronaut takes a certain kind of person. Ever since the selection of the original Mercury Seven, space agencies have tried to find people with 'the right stuff' to be an astronaut – the perfect blend of personality, knowledge, intellect and physical capability to travel to space and thrive there.

This year, BBC Two will attempt to find someone with just that potential by putting a dozen men and women through six weeks of astronaut training in a new TV show *Astronauts: Do You Have What It Takes?* The contestants face the challenges that await real trainee astronauts, tasks that will test all aspects of their fitness, skill, quick thinking and team work.

At all times they will be watched by an expert panel of judges: Canadian astronaut and former International Space Station commander Chris Hadfield, psychologist Dr Iya Whiteley and space medicine expert Dr Kevin Fong. Every week, the judges will send contestants home if they don't meet the cut as they try to decide who might make the grade.

BBC/JAMES CHEADLE X 3, GCTC

ABOUT THE WRITER

Dr Elizabeth Pearson is BBC Sky at Night Magazine's news editor. She gained her PhD in from Cardiff University.

BBC TWO

Astronauts: Do You Have What It Takes? will be broadcast on 20 August at 9pm on BBC Two.

The contestant

Jackie Bell is originally from Liverpool, where she gained her PhD in theoretical particle physics, and currently works as a guide at the Science Museum in London

What was it like to be on the show?

From the first day, it was exciting. We went into a hangar and Canadian astronaut Chris Hadfield turned up in a helicopter and told us, "You're going to fly one of these things right now." We got a 10-minute briefing and then we got put in the cockpit to hover the helicopter for as long as we could. That was the first challenge.

What were you most looking forward to?

I've known since I was a kid that astronauts train in a centrifuge, they do parabolic flights and underwater spacewalk training. Even though we didn't know it was guaranteed, that was on all our minds. There was something I wasn't looking forward to, though. I was training all through the selection process, but it was only when I was chosen that I realised, oh god, this is real… and I can't really swim.

There was a real panic the three weeks before the show as I tried to learn to swim. Every day a task was announced I was dreading it. Please don't make me swim, please don't put me under water.

What was the selection process like?

I have always wanted to be an astronaut, and this was probably the closest I am going to get. I had to apply. Once we were shortlisted we had interviews and were given group tasks to see how we coped under pressure, but I think the medical and psychological assessments were the most nerve-wracking, because it's out of your hands.

All the candidates who made it through to the final selection had a similar personality to real astronauts in that we're all quite selfless. One of the reasons I applied was that I have always felt very different to the people around me. So to be put with people who are very similar, for me that was really rare.

Was it hard to see the other contestants go home?

That was the hardest thing for me, personally, knowing that not everyone was going to get a chance to do all of the tasks. Everyone wanted everyone else to do well. Everyone deserved to be there. But if you don't perform, then you go. It was always on your mind.

Was being an astronaut trainee a tough experience?

Yes. Not only do you have to be very skilled, but if it were real you'd then have to actually get into a spacecraft on top of a rocket and launch, which is terrifying.

But if they turned around tomorrow and asked me to be an astronaut I would say yes. Definitely, 100 per cent.

The judge

Kevin Fong is a consultant anaesthesiologist who has worked with NASA's human adaptation and countermeasures office. He served as one of the judges on the show, helping to decide who would get sent home

What tasks did you set the candidates?

It was a very enviable set of tasks. We had them in the Dunker, a box that simulates an aircraft cabin, which is thrown in a swimming pool and they have to escape from. We spun them up to a few G in a centrifuge, had them do simulated spacecraft dockings on the real Soyuz simulation that astronauts train with, sent them diving in the Aquarius subaquatic habitat and doing parabolic flights. These were actual astronaut training facilities, or close representatives. Any single one of them would have been an incredible experience.

On the one hand, I was very envious, but on the other it was so hard to be under the microscope. Everything was a test and they felt that.

What were you looking for in the candidates?

We put them through their paces in these tasks to try and work out who was and wasn't suited to being an astronaut. It's difficult actually. With astronaut selection, there's no single character type or set of skills that makes you an astronaut. It's a cross section of the normal population, albeit a high-performing one. You're looking for the things that anyone will ask for in an astronaut: good at working in a team, good at working under pressure, has some operational experience in the real world.

But it's not just a test of skill. There is no unique personality type that makes someone an astronaut. In some ways, you don't know what you're looking for until you find it.

How did you choose who to send home?

You have to study them carefully, looking for something to differentiate them. I wasn't just studying how they accomplished an end task, but their attitude towards it.

We all had our own way of looking at them. Iya, because she's a psychologist who has worked on astronaut selection before, was really looking at their behaviours. I was much more operational in my approach – people who look good on paper aren't always good in a field environment under pressure. Chris had the advantage of being a veteran astronaut. He knew what astronauts look like.

These weren't random eliminations. We watched them evolve throughout the process and as the tasks went on, we took what we already knew about them into consideration. There was always some different aspect of their capability that was revealed each time. By the end I think we were making some informed decisions. Every single one of them all the way through looked like they might have been capable of applying to be a real astronaut. Anyone could have succeeded. ▸

The contestants used the actual Soyuz training facility that real astronauts use

The tests

The candidates were faced with challenges on land, in the air and even underwater

CENTRIFUGE

Spinning at high speeds, long-arm centrifuges can mimic the forces an astronaut experiences during take off and re-entry. Such high G-forces can pull blood away from the brain, or push down on an astronaut's chest making it difficult to breathe. Through sessions in the centrifuge, the trainees can learn how to tense muscles to maintain blood pressure in the head and learn breathing techniques to fight against these forces.

PARABOLIC FLIGHTS

To mimic the effects of microgravity, astronauts train on specially outfitted planes which repeatedly fly up and down at an angle of 45°. At the top of the curve, they experience around 20 seconds of weightlessness. As well as making passengers feel sick (earning the plane the nickname The Vomit Comet), candidates get a taster of using equipment specially adapted for use in space.

AQUARIUS UNDERWATER HABITAT

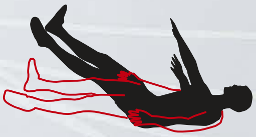
Located 6km off the coast of Florida, Aquarius is a subaquatic habitat 20m below the surface, where trainee astronauts live for weeks at a time. During their stay, the 'aquanauts' experience what it's like to live in an isolated environment where they rely completely on life support systems. It also helps develop good expedition behaviour, the art of keeping morale up and working as a team, which is vital on the ISS.

THE DUNKER

An underwater escape training unit, the Dunker is a mock cockpit that can be repeatedly dropped into a swimming pool so that pilots can practise exiting the aircraft in the event of a crash. The tests are often done in the dark or with key routes blocked so trainees have to learn to keep calm to make their escape. Often the unit is flipped to odd angles to assess how trainees deal with emergencies while disorientated.

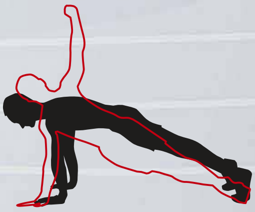
Can you train like an astronaut?

Astronauts do specific exercises to train their bodies for space, which you can follow at home



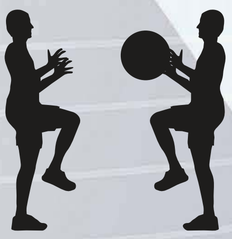
BACK

Lie face up on the ground, lift your legs and arms then return to the start position. Repeat five times, slow and controlled.



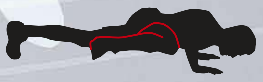
CORE

Alternate between a front plank and a lateral plank with arm raise, holding each for 30 seconds. Repeat three times.



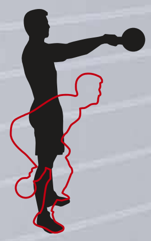
BALANCE

Stand on one leg and throw a ball back and forth with a partner. Repeat three times for 30 seconds on each leg.



AGILITY

Assume a press-up position and lift one knee to your elbow. Return and then repeat with the other knee. Continue for 30 seconds, repeat three times.



STRENGTH

Holding a kettlebell in both hands, squat down and swing the weight from between your legs to chest height for one minute. Repeat three times.

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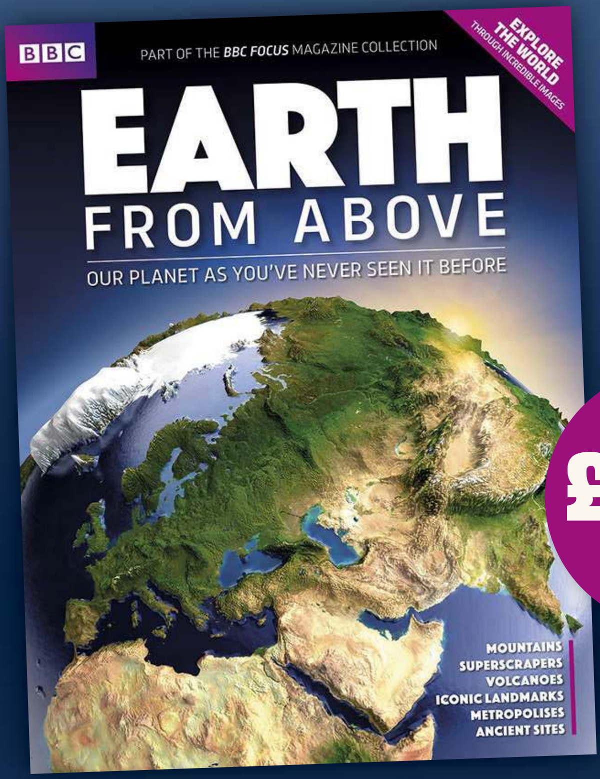

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Brush up on your astronomy prowess with our team of experts

The Guide

With
Paul Money

Getting to grips with altaz mounts

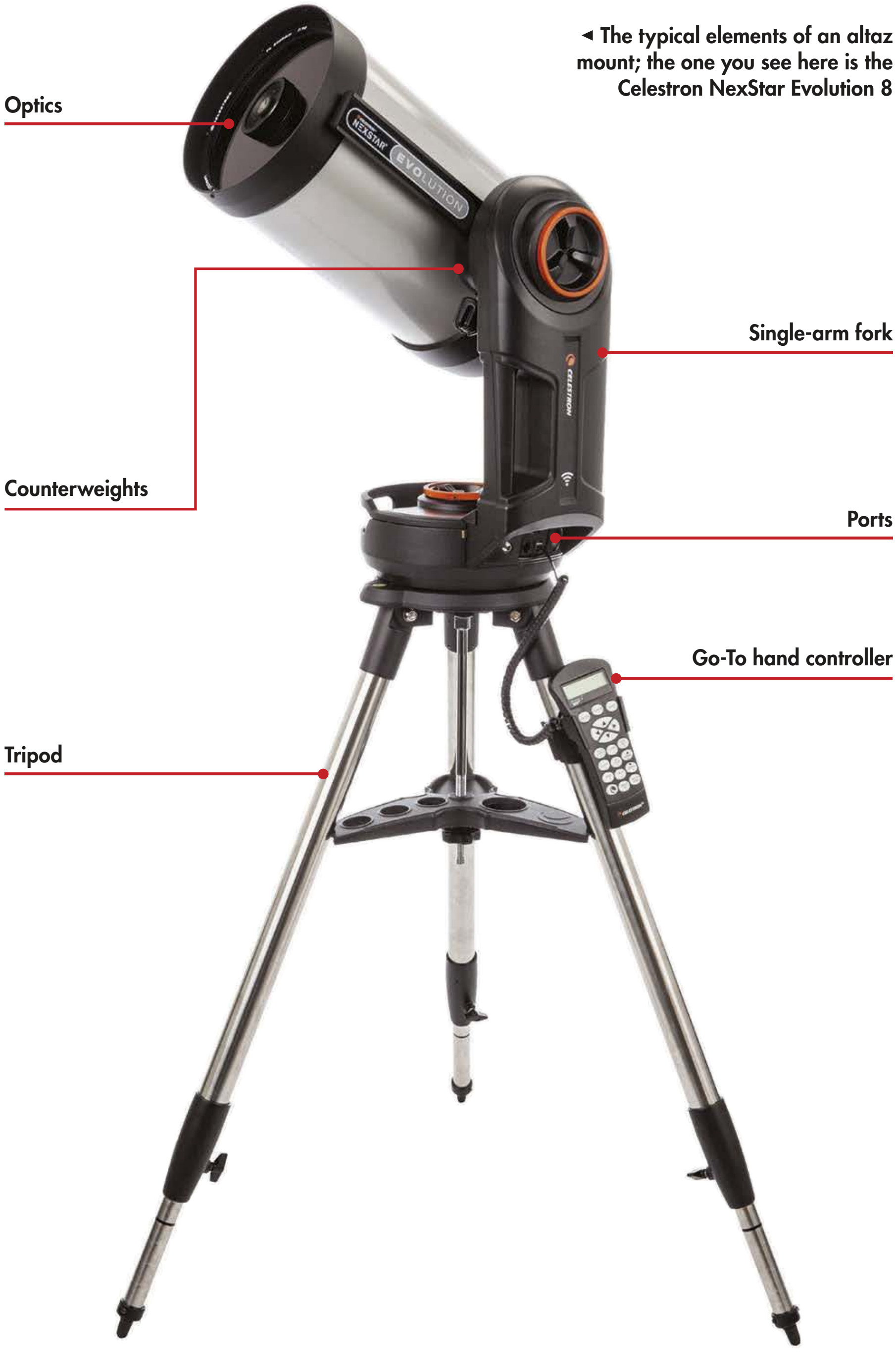
What altaz mounts are, how they work and why ‘simple’ doesn’t always mean ‘bad’

Altaz mounts can be regarded as the oldest form of mounting for a telescope. They have two axes of rotation, one level with the horizon and the other moves in elevation (altitude). ‘Alt’ derives from altitude and ‘Az’ from azimuth, the latter being the position measured from north, usually through east along the horizon. Last month we looked at equatorial mounts, which are technically altaz mounts tilted so that one axis is aligned with Earth’s polar axis.

Unlike equatorial mounts, altaz systems don’t track the stars, but they are quick and easy to set up. Unpowered versions require no alignment whatsoever. The simplest forms are push-pull variants and Dobsonians (we’ll cover this second variant in detail next month), where you either manually move the scope and point it at your target or have simple slow-motion controls to move the mount.

Growing sophistication

With the advent of computerised, motorised ‘Go-To’ systems, altaz mounts have become more sophisticated. Some now support Go-To, and can track targets in the night sky once an alignment process has been completed. Initially this technology was limited to high-end, high-cost systems, but no longer. Single- and dual-arm altaz mounts are now widely available, for example the Meade ETX, Celestron NexStar and Sky-Watcher SkyMax series. iOptron has also launched an unusual take on the design with the iOptron AZ Pro, where the mount has been designed as a cube. Such systems have helped bring Go-To technology to a wider audience



◂ The typical elements of an altaz mount; the one you see here is the Celestron NexStar Evolution 8

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ALTAZ MOUNT VARIANTS

Single arms are the 'standard' but, as with EQ mounts, there are others

PUSH-PULL
The simplest altaz design, push-pulls have no drives on either axis. You manually move the telescope on a simple tripod. These make great, simple to operate and relatively cheap systems for beginners. Birdwatching spotter scopes on a tripod can also be used for visual astronomy in the same way.

DUAL-ARM FORK
For larger aperture telescopes, turn to a dual-fork mount. By supporting the optical tube between the two arms the weight is spread evenly between them for greater stability. Many dual-arms support equatorial wedges, meaning they can be used for deep-sky astrophotography.

TTS PANTHER
The TTS 160 Panther altaz mount from Track The Stars is a portable system that has all the same features and connectivity as other altaz Go-To systems, and with the addition of an optional 'telescope rotator' it can also be used for deep-sky astrophotography.

and to beginners who don't mind the extra cost involved compared with basic mounts and telescopes.

Unlike equatorial mounts, altaz mounts don't follow the sky smoothly in an arc as they aren't lined up with Earth's polar axis. This leads to 'field rotation' in altaz systems, which poses a problem for anyone interested in deep-sky astrophotography. Field rotation occurs because the altaz view remains lined up in relation to the horizon, whereas your celestial target moves with the sky, so when you stack multiple images they won't align. For visual purposes, this doesn't matter, you just keep on adjusting the mount to keep your target in view. If your primary interest is simply viewing the night sky, or perhaps taking short videos of Solar System targets, a Go-To altaz setup could be an ideal choice.

All is not lost, however, if you do want to try out deep-sky astrophotography with an altaz mount as two things can help. First, camera technology. Many modern DSLRs and CCDs can capture good detail in short exposures, take a lot of them and then stack them. Stacking software such as the free DeepSkyStacker can deal with the rotation you will see in the images. Second is an accessory called an equatorial wedge, which some manufacturers produce for their altaz systems. This add-on effectively turns the mount into an equatorial one, making long-exposure imaging possible.

Single-arm mounts can usually hold telescopes up to 8 inches in aperture and are typically supplied with an adjustable tripod. There will be a mounting bracket for either a Losmandy- or Vixen-style mounting bar, and often ports for connecting a Go-To hand controller and an external power supply. Some will have extra ports for other accessories. Most mounts also have a battery compartment for cable-free operation.

Computerisation has revolutionised altaz mounts: some can now be controlled wirelessly, using an app on a tablet or smartphone. Whether you want a straightforward push-pull system, one with Go-To, or one with dual arms, there is an altaz option out there for you. Ⓢ

Paul Money is *BBC Sky at Night Magazine's* reviews editor

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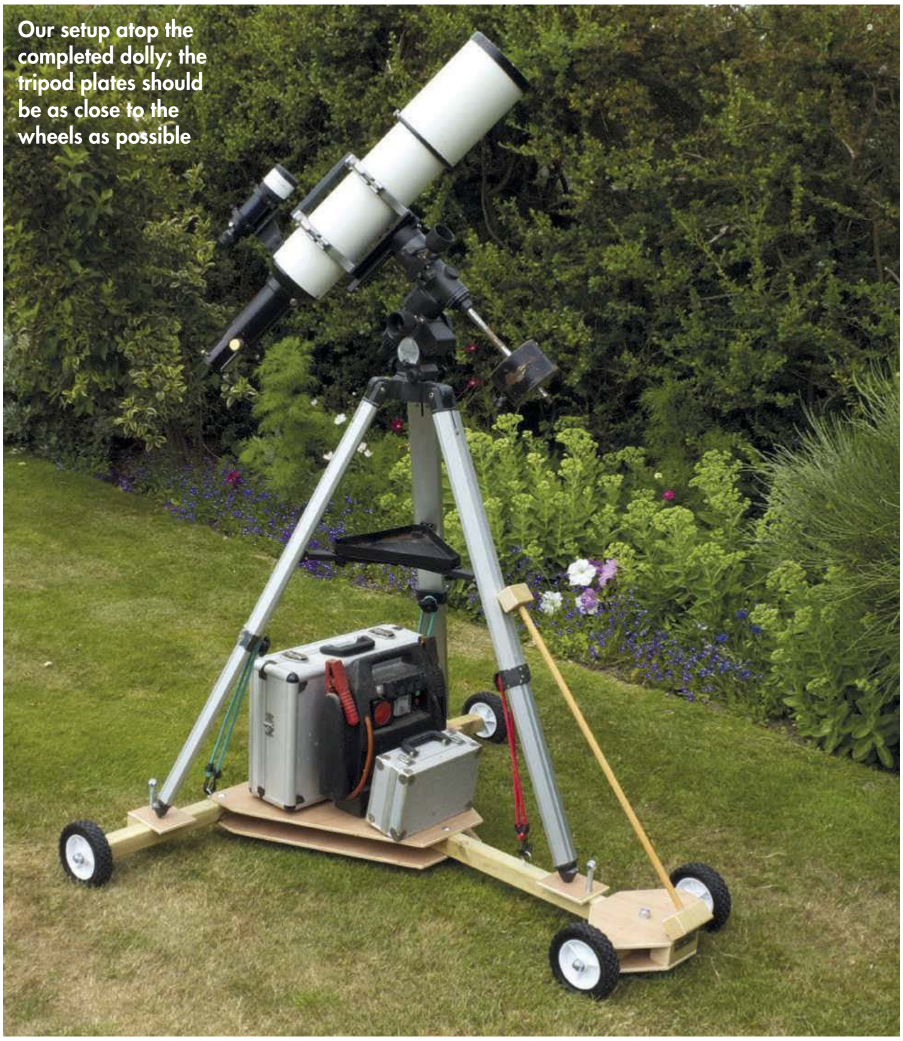
How to...

Build a rolling dolly

Wheel your setup in and out of storage without delay

YOUR BONUS CONTENT

Download templates for this project in this month's Bonus Content



Our setup atop the completed dolly; the tripod plates should be as close to the wheels as possible

Most medium-sized mounts and telescopes are too heavy and unwieldy to move once they've been assembled, which means setting up and packing away each night can become a slog. There's the numerous journeys back and forth to the garden, for one. Refitting mount heads and weights takes up time when you could be out observing, and rebalancing a telescope can be fiddly work in the dark. It is also all too easy to misplace leads and small parts.

This month's project, an inexpensive rolling dolly, provides a workaround. Leave your fully assembled setup on top of it and whenever the skies are clear you can simply roll the whole unit into position. If the weather turns against you, you can be back in the warm in next to no time, secure in the knowledge that nothing is left behind.

The timber for the dolly's axles can be readily obtained from a builder's merchant. We chose 'prepared' (planed) 45x45mm timber because it is nice to handle and can be painted to match your other equipment. The plywood parts provide bracing: we made ours from 9mm thick sheet, but you could use a slightly different thickness if you already have some available. The dolly frame needs to be rigid, but as most of the scope's weight is supported close to the wheels it doesn't need to be too heavy. Individual parts are bolted together, allowing you to take the dolly apart for easy storage or transport. Furthermore, the design allows for re-sizing should you ever decide to upgrade your tripod.

Downloadable plans are available in the Bonus Content. They show dimensions for our example dolly, and these measurements should suit most small to medium tripods. We have indicated the positions we drilled holes in the bracing plates, but we'd recommend lining up your beams and tripod support plates with your own tripod to determine the best position for these holes before

ALL PICTURES: MARK PARRISH

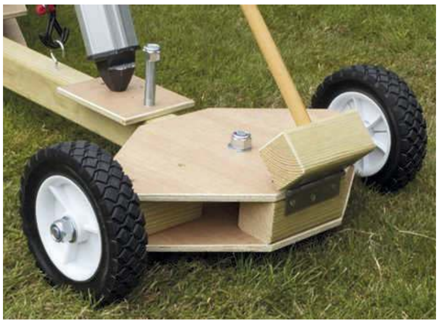
TOOLS AND MATERIALS

TOOLS
Handsaw or jigsaw, hacksaw, drill and bits (for 12mm and 8mm bolts), spanners, screwdriver.

MATERIALS
Approximately 3m of 45x45mm construction timber, 1,200x600mm sheet of 9mm plywood, length of suitable timber or rope for the handle.

SUNDRIES
Four 150mm-diameter wheels with rubber tyres, 1m of M12 studding (diameter to suit wheels) with nuts and washers, six M8x75 bolts, 75mm butt hinge, epoxy resin glue, 25mm woodscrews.

FINISH
Preservative wood stain or paint.



▲ The steering mechanism and the rigid handle; for a soft handle, use some rope

drilling. Ideally the wheels and jacking points should be as close to the tripod feet as possible. For wheels, we chose 150mm plastic ones with rubber tyres. These run well on M12 studding axles and they seem to cope with regular gravel drives and garden lawns. Because the speeds involved are low and distances relatively short, pneumatic tyres and proper bearings are not necessary unless you are scaling up the design for a heavyweight mount or you have particularly bumpy ground to cover.

Finessing the design

If your tripod legs have slightly pointed feet, a simple hole drilled in the leg support plate will help locate them. If you have a tubular design you could make L-shaped corner blocks and screw them into each plate to prevent your tripod from sliding off. Tying your tripod down with straps or bungees is also a good idea, in case you bump against something or have to stop suddenly. The last thing you want is for your setup to pitch forward and crash to the ground.

On the front of the dolly is a rigid towing handle. It attaches to the front of the steering mechanism via a hinge, so it can be folded back against the tripod when not in use. You could also use a loop of rope or webbing as a simpler alternative. When you have your dolly in position, screw down the jacks to stop it moving accidentally. Once you are polar aligned, you could also mark the jack positions on the ground to aid repositioning on future nights.

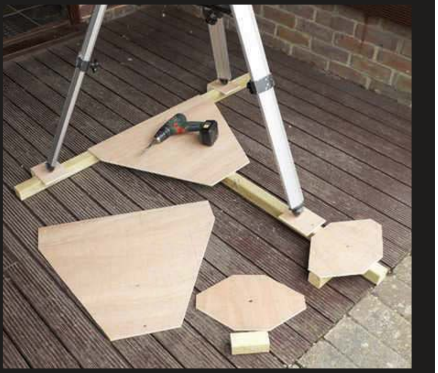
We also found that the bracing plate below the tripod is ideal for holding accessory cases and a power tank, but you could consider customising this area to provide specially made racks and boxes for your accessories and imaging equipment. Ⓢ

Mark Parrish is a consummate craftsman. See more of his work at buttondesign.co.uk

STEP BY STEP

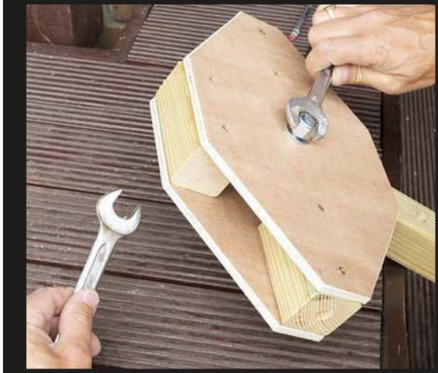
STEP 1

After carefully marking out the parts, use a saw to cut them to size. You can tape multiple plywood parts together and cut in one go so they match each other. If you have access to a band saw or jigsaw you could save some time here.



STEP 2

Drill the holes in plywood parts first, then line them up with the axles. Place your tripod on top to check size. Mark through the holes to find out where to drill into the axles. Do this, then assemble the timber and plywood parts.



STEP 3

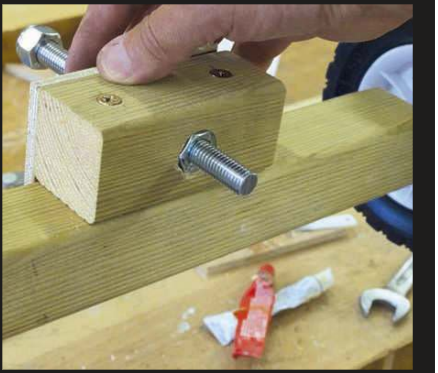
Make the steering 'box'. It's held together with 25mm woodscrews inserted through the plywood plates into the axle and front blocks. A piece of studding provides a pivot. Use Nylock nuts and washers and make sure it turns smoothly but is not wobbly.

STEP 4

Cut lengths of studding for the axles using a hacksaw. Allow enough for a nut and washer either side of the wheel, plus about 50mm to be glued inside the wood. File the ends of the studding so they aren't sharp and the nuts fit on nicely.

STEP 5

Check the wheels spin without wobbling. Use epoxy resin to glue each axle in, taking care not to get any glue on the moving parts. If the wheel needs to be removed later on you should be able to simply undo the outer nut.



STEP 6

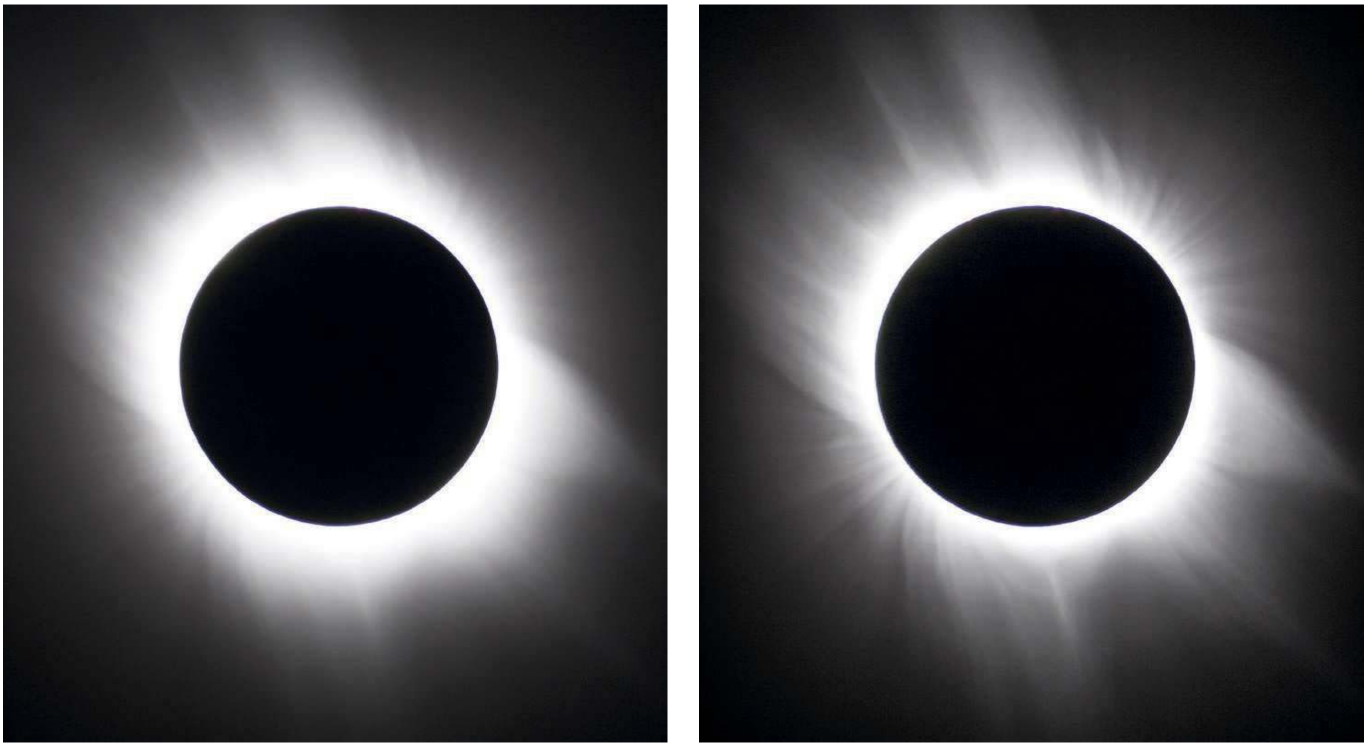
Once the tripod foot plates and jack blocks are screwed into position, drill through both for the studding. An enlarged hole on the underside gives you room to glue in a captive nut (normal type). Use a Nylock nut (or a wooden disc) to make the upper turning knob.

Image PROCESSING

With **Daniel Lynch**

Revealing coronal detail in solar eclipse images

Elevate your eclipse photos and see the full majesty of the Sun's plasma aura



▲ Editing each frame before stacking can make a huge difference to detail; on the left is an untouched still, right the same frame after minor editing

The total solar eclipse of 21 August 2017 will probably be the most photographed in history. If you want to make your images of the eclipse stand out, you'll have to go the extra mile. One way to do that is to stack your images to enhance detail in the Sun's corona.

The corona is made up of the bright inner corona and the dimmer outer corona. While our eyes are excellent at handling the difference in brightness, cameras are not. This difference in brightness is called dynamic range. Here we outline a method to achieve high dynamic range (sometimes abbreviated to HDR) for your eclipse photos using three photos taken in Libya in 2006. They were captured using a Canon EOS 20D DSLR attached to a Bresser 70mm refractor that cost only £50, tripod included. It's amazing what results you can get with even modest equipment.

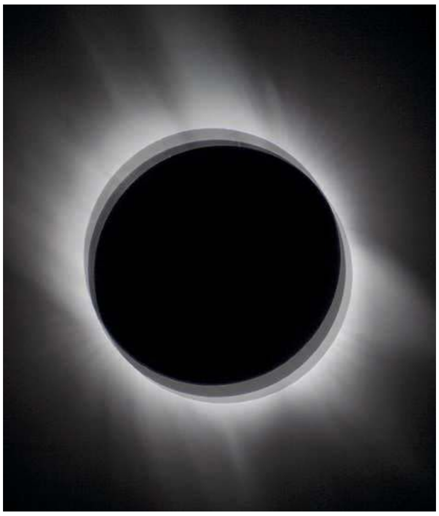
We shot in RAW mode to achieve the best image quality. The telescope wasn't motor-driven, which adds to the challenge of stacking the images, but we'll also show you how to align your photos in Photoshop to overcome this problem.

Process individually first

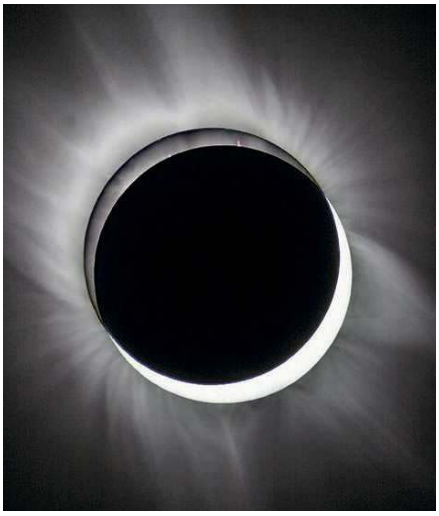
Choose several photos of totality that have different camera settings. Preferably, you want images of the inner and outer corona. It is a good idea to process each photo individually before stacking them. Our recipe for preparing each image starts with opening them in Adobe Bridge. Right click on your first image and select **Open in Camera Raw**. Set the clarity slider to +75 to show the finer detail of the corona and the shadow slider to +10 to enhance it. Save the file by clicking **Done** and repeat for all the photos you will be stacking. Already you should see a big improvement in each of your individual photos. Now we are ready to stack the images to bring out even more detail.

Open Adobe Bridge and select each of the prepared images by holding down Ctrl and left-clicking each image. Click **Tools** > **Photoshop** > **Load Files into Photoshop Layers** to open them in Photoshop. They will be visible on the right-hand side as separate layers. In the layers tab on the right-hand side, highlight each layer by holding down the control button and single-clicking them. Make them smart objects by clicking **Layer** > **Smart Objects** > **Convert to Smart Object** – doing so preserves the original photos and allows us

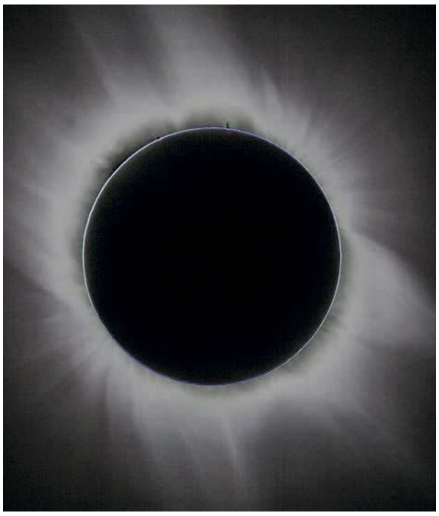
ALL PICTURES: DANIEL LYNCH



▲ Photos taken with untracked mounts will not line up properly – but this can be fixed



▲ Setting the layer blend mode to Difference will help when you align the solar discs



▲ The solar discs aligned, but the blending mode is still Difference; that needs changing

to edit the images without reducing their quality. We are now ready to stack. Click **Layer** > **Smart Objects** > **Stack Mode** > **Objects** > **Mean**. We have now stacked the images and taken the average of the exposures to give the best result.

If your photos were captured with a setup that included a driven mount, they should be perfectly aligned. You're done! If your setup did not track with the motion of the sky, then you will have a clear problem. The stacked images won't line up over each other.

Aligning the layers

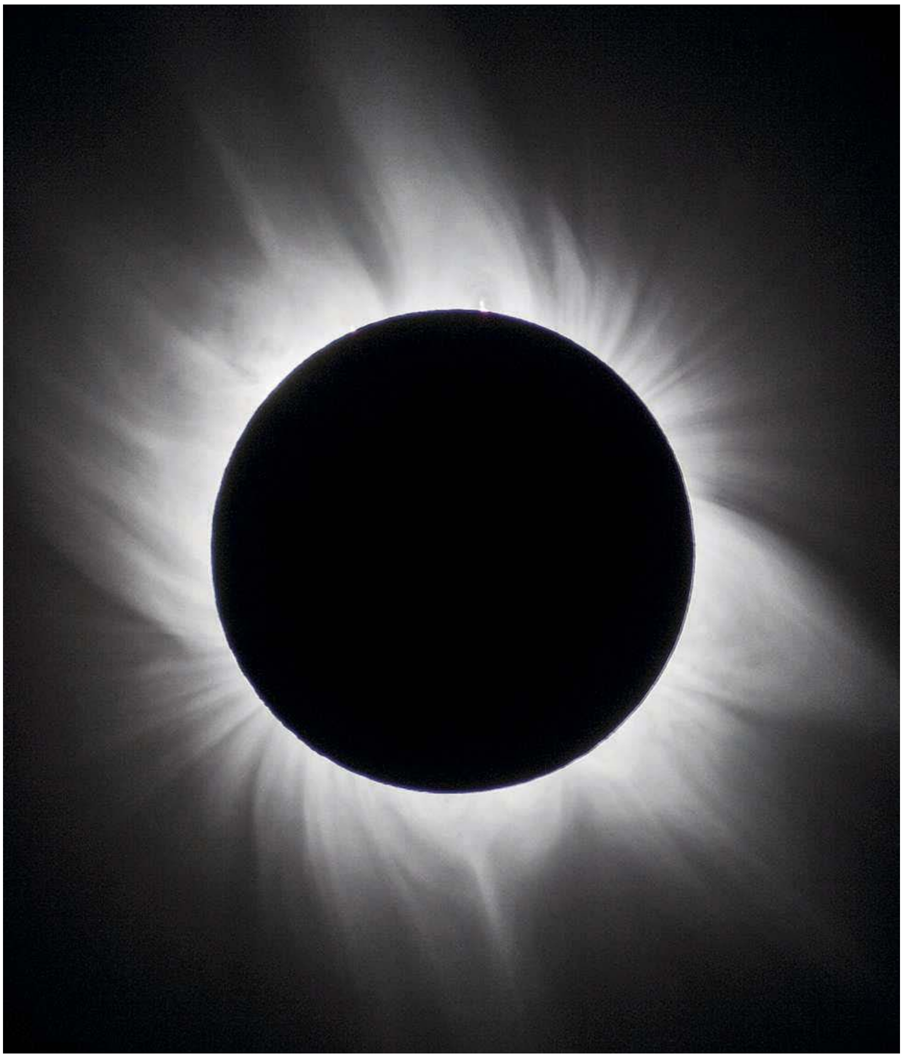
Thankfully there is a way to fix this alignment issue. It can be a little tricky to follow, but it's easier than lugging a tracking mount halfway across the world. In Photoshop's layers channel, highlight each layer by holding down Ctrl and left-clicking it. Above the highlighted layers, in the Blending mode drop-down menu (which is Normal by default), select **Difference**. This will guide you in lining up your images.

In the layers channel, turn off the visibility of every layer except for the top one. You can toggle visibility of any layer on and off by pressing the eye icon beside it. Highlight the second layer from the top only (hold Ctrl and left click) and then make it visible. The difference between the pictures should now be apparent.

Use the move tool (find it in the toolbar on the left) to drag this second layer over the top one so as to leave no difference. You can also do this by holding down Ctrl and using the arrow keys.

Repeat the process for every layer. Make sure that only the top layer and the layer you are moving are visible. Also make sure that the layer you are moving is the only layer highlighted. Once every layer is aligned, select each one (hold Ctrl and left click) and change the Blending Mode back to **Normal**. Finally, you have the eclipse image you were looking for.

DANIEL LYNCH is a veteran eclipse chaser whose images have appeared in *The Wall Street Journal* and *Time*



▲ The final image, achieved by simply reverting the blend mode to Normal. Detail in the corona is much greater and more subtle here compared to a single frame

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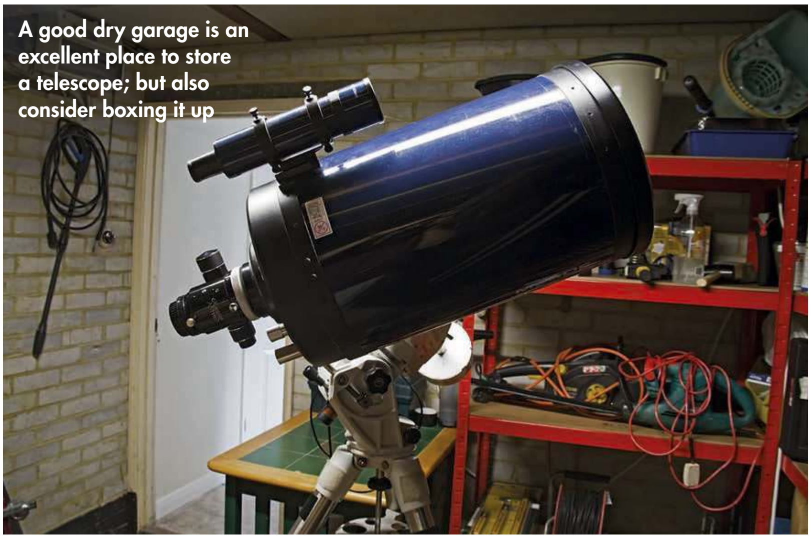


A good dry garage is an excellent place to store a telescope; but also consider boxing it up

I am planning to store my Meade LX90 in an airtight and waterproof box in a brick garage. What else should I consider?

CHARLES MCCAUL

Telescope storage is a common problem for astronomers as the unwieldiness of our instruments is not always compatible with family life or smaller dwellings!

The main requirements for safe storage are that the storage area is secure, dust-free, dry, free from extreme temperature changes but ideally cool, and easily accessible. Outbuildings make useful storage areas and a brick-built garage like yours is a good starting point, although the roof construction and position with regard to the Sun are important considerations.

Temperature stability is a bonus because temperature changes and high humidity levels result in condensation, which should be avoided at all costs. Your sealed box will offer some good protection from this. The advantage of a cool environment is that the temperature stabilisation, which is so important at the start of an observing or imaging session to avoid tube currents, will be achieved quicker – thus extending your time at the eyepiece.

Storing your telescope in a well-sealed box, as you intend, will protect it from dust and direct water ingress, but there is still the potential for moisture from the air to gain access. Because of this it would also be worthwhile placing some silica gel inside the box as a precaution.

Always ensure that the telescope is free from condensation before returning it to its box by leaving it in a dry area for a few hours first.

PETE LAWRENCE, STEPHEN TONKIN

Simply lying back in a camping chair will alleviate some strain

I have a pair of binoculars, but struggle to keep them steady. What's the best way to stabilise them?

JO COCHRANE

Binoculars are a really great way of enjoying the night sky as a wide range of fascinating celestial objects can be observed through them. However, after a relatively short period of observing, your neck muscles may well start to ache and soon after that, your arm muscles will start to complain at the weight. It is at this point that the view will start to waver as you fail to hold the binoculars steady.

A low cost, low tech solution is to simply lie back on a sun lounger. However, there are technical solutions ranging from simple altaz mounts on a basic tripod through to substantial parallelogram mounts such as the Orion Paragon-Plus. You can even make or buy a simple cradle with a front silvered mirror that will allow you to look down at the reflection of the night sky in a very comfortable seated position. Have a look at the ScopeTeknix Binoflex ST50 mirror binocular mounting.

STEVE'S TOP TIP

How do I calculate the magnification of my eyepiece?

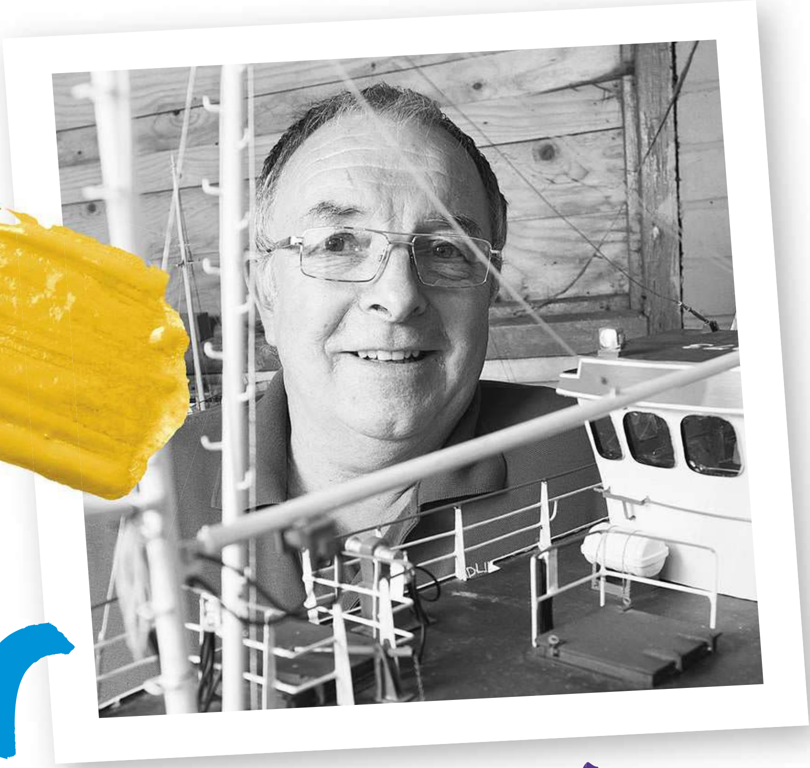
It can often be useful to know what magnification you are using when observing the night sky, especially if you are following someone else's guide to observing a particular object.

Magnification is affected by two parameters, the focal length of the telescope and the focal length of the eyepiece. The telescope focal length can usually be found on a plaque attached to the telescope and most eyepieces have their focal length silk screen printed on the barrel.

To find the magnification of your telescope/eyepiece combination, simply divide the telescope focal length by the eyepiece focal length in the same units.

Steve Richards is a keen astro imager and an astronomy equipment expert

Email your queries to scopedoctor@skyatnightmagazine.com



Arthur strikes back

Severe stroke survivor makes model recovery

When stroke attacked Arthur Pickering, aged just 58, he thought he would spend the rest of his life in a care home.

And no wonder.

Stroke is the UK's leading cause of severe adult disability, as well as our third biggest killer.

But then, Arthur struck back.

With the help and care of the Stroke Association, he went from being semi-paralysed, speechless, and unable to grip a tennis ball, to building a devilishly detailed 4′ 6″ monster model of the world's biggest ferry.

Then he sailed away with first prize at the Blackpool Model Boat Show.

Helping people like Arthur is the work of the Stroke Association - **and the very best way you can help us strike back against stroke is to leave us a gift in your Will.**

Stroke
association

To find out how you can help us strike back against stroke by leaving us a gift in your Will, please call 020 7566 1505 email legacy@stroke.org.uk or visit stroke.org.uk/legacy

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BBC Sky at Night MAGAZINE

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Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

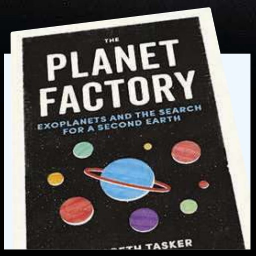
Each category is given a mark out of five stars according to how well it performs. The ratings are:

★★★★★ Outstanding
★★★★☆ Very good
★★★☆☆ Good
★★☆☆☆ Average
★☆☆☆☆ Poor/Avoid

Is colour fringing consigned to the past with the AIRY APO 65F's FPL-53 triplet lens? **90**

SEE INTERACTIVE 360° MODELS OF ALL OUR FIRST LIGHT REVIEWS AT WWW.SKYATNIGHTMAGAZINE.COM

This month's reviews



FIRST LIGHT

90 PrimaLuceLab Airy APO 65F apochromatic refractor

94 iOptron SkyGuider Pro tracking mount

98 QHYCCD QHY367C CMOS colour camera

BOOKS

102 We rate four of the latest astronomy titles

GEAR

104 Including these Vixen HR planetary eyepieces

Find out more about how we review equipment at **www.skyatnightmagazine.com/scoring-categories**

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FIRST **LIGHT**

See an interactive 360° model of this scope at
www.skyatnightmagazine.com/airyapo65f

PrimaLuceLab Airy APO 65F apochromatic refractor

A three-element FPL-53 scope that takes aberration avoidance seriously

WORDS: PETE LAWRENCE

VITAL STATS

- **Price** £793
- **Optics** FPL-53 triplet objective with integrated FPL-53 field-flattener
- **Aperture** 65mm (2.5 inches)
- **Focal length** 420mm (f/6.5)
- **Focuser** Hybrid drive focuser (Crayford-style plus lockable rack and pinion) with 60mm movement
- **Extras** Tube rings, 1.25-inch OnAxisLock adaptor
- **Weight** Tube 2.3kg, tube rings 0.5kg
- **Supplier** 365 Astronomy
- **www.**365astronomy.com
- **Tel** 020 3384 5187

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Many regard refractors as the perfect design of telescope, giving high-contrast views thanks to the lack of the central obstruction found in mirror-based instruments. On the downside, large refractors are expensive and can be unwieldy. PrimaLuceLab's Airy APO 65F is small enough at 2.5 inches to be both affordable and manageable.

One negative effect of using a lens is chromatic aberration, where the main lens is unable to bring all visible wavelengths to a common focus, resulting in colour fringing. The Airy APO 65F uses a three-element FPL-53 glass objective to address this issue. A fully colour-corrected telescope is termed apochomatic, APO for short. The 420mm focal length makes this a relatively fast (f/6.5) instrument. Coupled to a Canon EOS 6D full-frame DSLR, we produced images covering a 2.1x1.7° rectangle of sky, an ideal size for extended objects such as star clouds, open clusters, nebulae, and galaxies like M31 and M33.

Fast instruments can suffer from coma, which leads to distorted stars towards the edge of frame and is normally addressed by attaching your own field-flattener between scope and camera. The Airy APO 65F possesses a permanent flattener made from FPL-53 glass, fitted internally.

SKY SAYS...
Biased towards wide-field, low-power views, this is a scope best suited to stunning deep-sky vistas

Testing during the summer gave us a good choice of star clouds and large, expansive nebulae to pick from. To a large format imaging sensor objects such as the North America Nebula in Cygnus, NGC 7000, provide a tough test subject, with a field of view covered with stars right across the frame. Using our Canon EOS 6D DSLR, the Airy APO 65F delivered some excellent results: stars at the centre of the frame appeared pin sharp, with only the slightest hint of distortion creeping in towards the extreme corners. Our large sensor test produced only slight vignetting in the corners of the image.

Easy grip, easy grasp

The scope uses what's called an OnAxisLock mechanism to hold equipment into the focuser drawtube. This is an alternative to the traditional thumbscrew locking found on most focusers and works by having a large, easy-grip locking ring that causes an internal collar to tighten around the barrel of whatever has been inserted when tightened. A 1.25-inch OnAxisLock adaptor, using the same principal, is supplied to complement the ▸

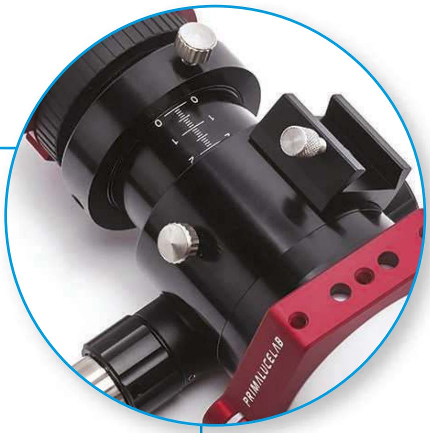
OBJECTIVE TRIPLET LENS

Refractors make superb deep-sky imaging instruments because of their contrast performance. To get the best results the optics need to bring all colours of light to focus at the same point. The triplet objective lens at the heart of the Airy APO 65F is designed to do just that. Using three FPL-53 glass elements, all colours are brought to a single focus leading to a clean image that is free from unwanted colour fringing.

FPL-53 is an optical material that attempts to replicate the exemplary optical properties of fluorite, a material that is easily damaged, expensive and not particularly environmentally friendly. Stronger, cheaper and greener alternatives are now popular. The FPL-53 name indicates that the glass is made from a fluorite-lead compound (F = fluorite, P = lead) with a low refractive index (L) and is the 53rd member of the material's development family. In use, we didn't encounter any colour fringing even around bright extended objects, and found the optical qualities of the scope to be excellent.

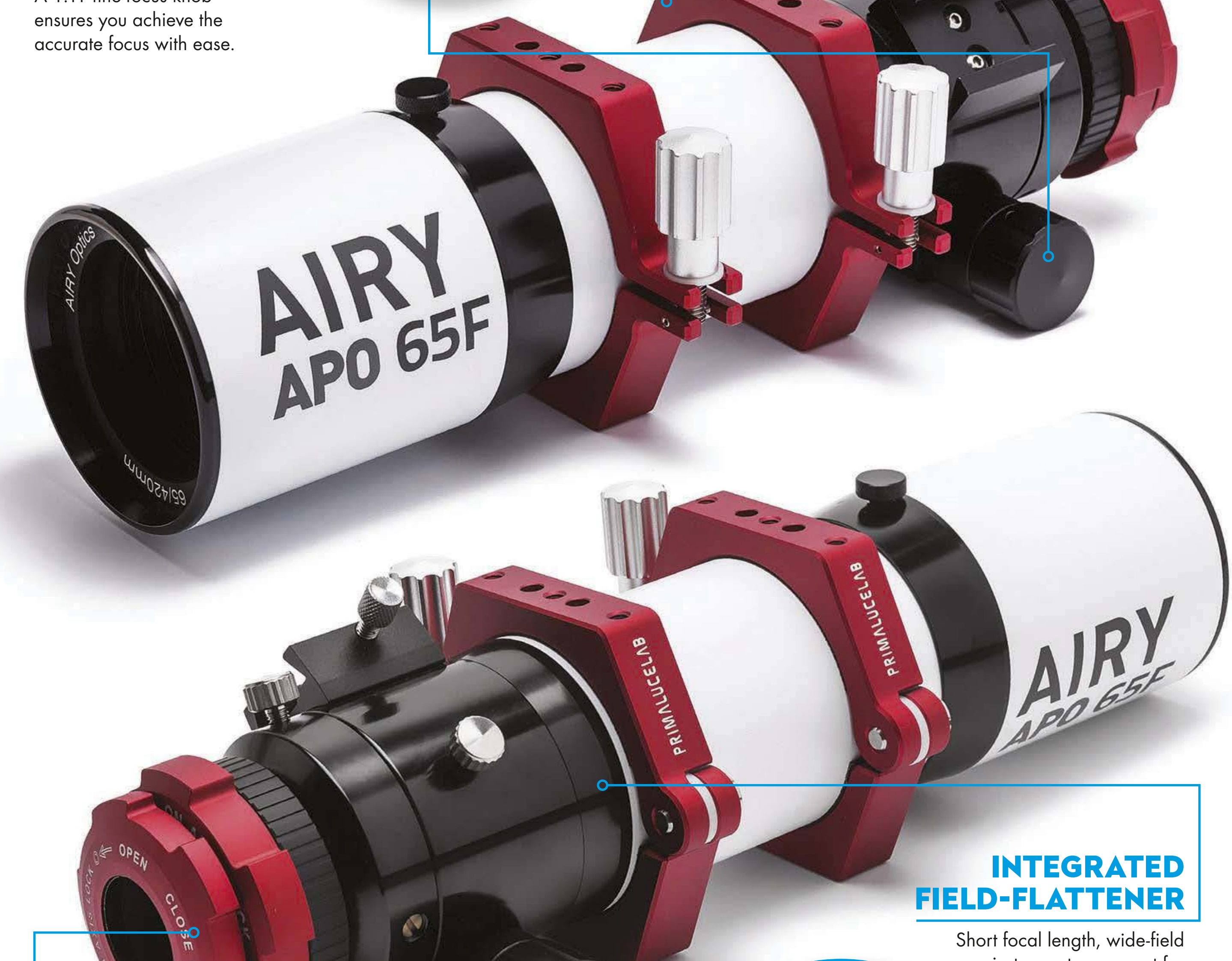
HYBRID DRIVE FOCUSER

The hybrid drive focuser combines the qualities of a Crayford-style focuser with that of a lockable rack and pinion. This produces a fast, smooth focusing action that won't slip with a heavy camera attached at high angle. A 1:11 fine-focus knob ensures you achieve the accurate focus with ease.



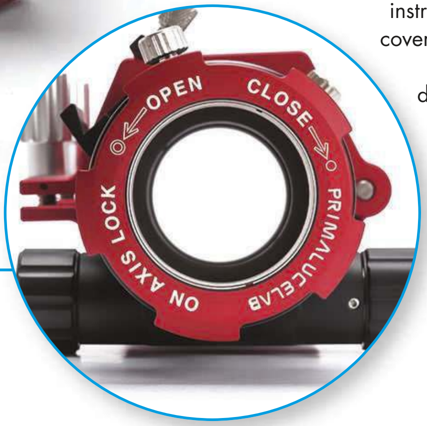
PLUS TUBE RINGS

The substantial and beautifully machined PLUS (Prima Luce Universal System) support rings clamp the scope for mounting. Three pre-threaded M8 female screw-holes and two head-recessed non-threaded holes are provided on the top and bottom of each ring. This gives excellent flexibility for both mounting the scope on a dovetail as well as attaching extra kit on top.



INTEGRATED FIELD-FLATTENER

Short focal length, wide-field instruments are great for covering large sky areas, but are prone to distortions noticeable at the edge and corners of the imaging field. This can be a big problem if you're using a camera with a large sensor. The Airy APO 65F contains an internal field-flattener made from FPL-53 glass.



ONAXISLOCK

The Airy APO 65F has a serious camera connector in the shape of the OnAxisLock system. The telescope offers a 2-inch fitting as standard and a 1.25-inch adaptor is supplied. A locking ring ensures the barrel of attached equipment is held securely and exactly on the central optical axis of the scope.

FIRST LIGHT

▸ built-in 2-inch version. The mechanism's design means that anything locked in place will be perfectly on-axis with the main telescope.

The grip-ring is chunky and usable even when wearing gloves, but we found that the system tends to rotate the inserted equipment during tightening. The focuser itself allows full 360° movement, so this isn't too much of an issue. We also found that barrels with recessed sections needed special care, because the reduced diameter of the recessed ring didn't always grip properly with the 1.25-inch adaptor.

Cancelling creep

A dual-speed hybrid drive focuser merges Crayford-style friction focusing with the direct action of a rack and pinion focuser, and gave us one of the best focuser experiences we've ever had. The movement was smooth, responsive and direct, with the 1:11 fine focus knob producing no backlash. The focuser design eliminates the creep that sometimes occurs when using a heavy camera at a steep angle, which can cause the focuser to extend. We couldn't budge it even when reasonable manual force was applied.

Using our own diagonal and eyepieces, the Airy APO 65F delivered high-contrast views free from any colour fringing. The bright gibbous Moon, viewed at 84x magnification, appeared beautifully detailed. We could make out the 6km-diameter crater Hadley C quite convincingly, but the nearby Hadley Rille escaped us. At low magnification, we were delighted to see the Moon and stars visible in the field of view. With a 20mm eyepiece giving a magnification of 21x, it was wonderful to sweep along the Milky Way's rich star fields. The stars really do look vibrant with the scope's superb contrast.

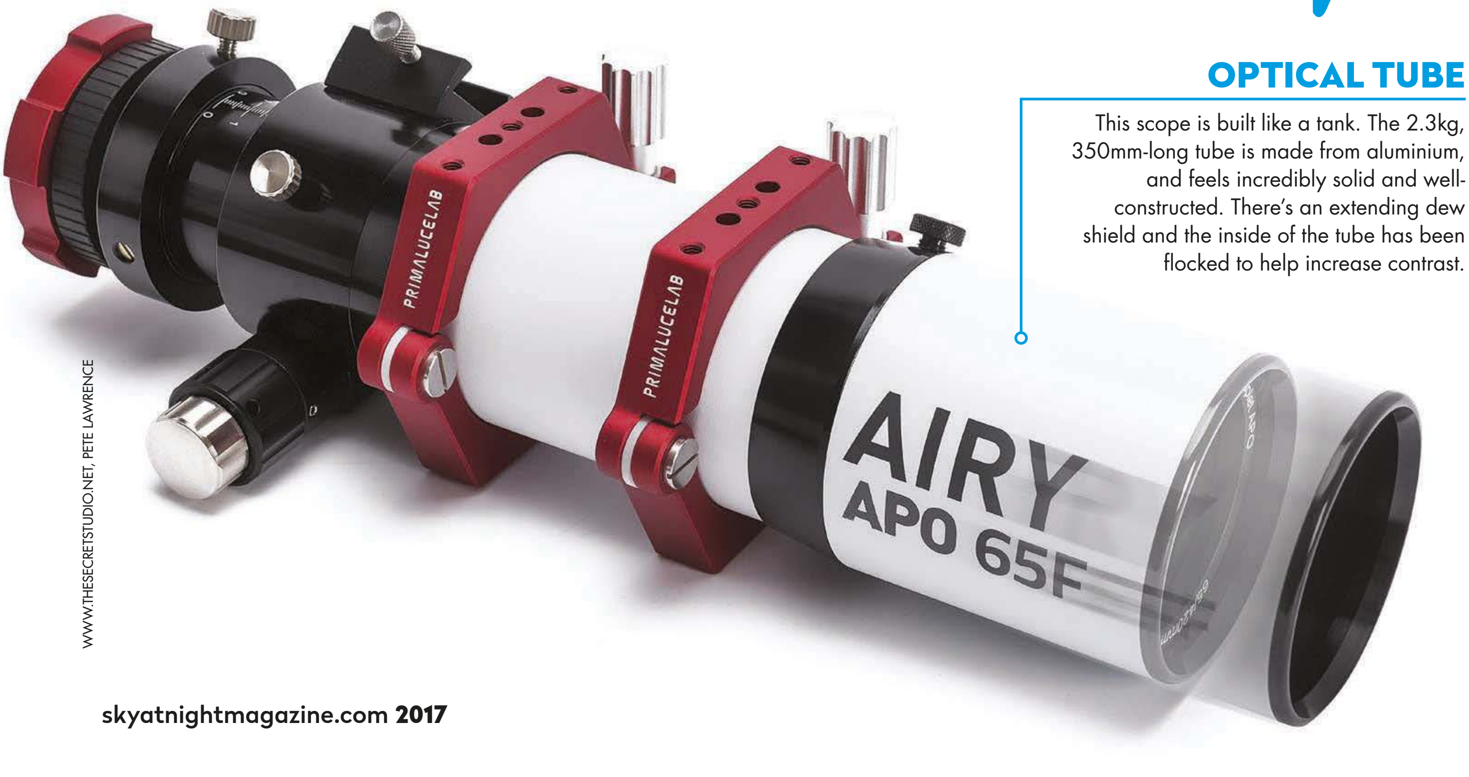
Excellent stars were visible across this image of NGC 7000, shot with a full-frame unmodified DSLR

This is a great grab-and-go scope with some nicely thought out features. It is supplied with a set of Prima Luce Universal System (PLUS) tube rings for mounting, but you'll also need a dovetail. Its short focal length isn't particularly demanding in respect of its mount, unless you intend to use it for seriously long exposures. Biased towards wide-field, low-power views, this is a scope best suited to stunning deep-sky vistas. Ⓢ

VERDICT

BUILD AND DESIGN	★★★★☆
EASE OF USE	★★★★☆
FEATURES	★★★★⯪
IMAGING QUALITY	★★★★⯪
OPTICS	★★★★☆
OVERALL	★★★★⯪

SKY SAYS…
Now add these:
1. Canon EOS 700Da astro-modified cooled DSLR camera
2. PrimaLuceLab Eagle Core DSLR control unit
3. Optolong L-Pro Max luminosity filter



OPTICAL TUBE

This scope is built like a tank. The 2.3kg, 350mm-long tube is made from aluminium, and feels incredibly solid and well-constructed. There's an extending dew shield and the inside of the tube has been flocked to help increase contrast.

WWW.THESECRETSTUDIO.NET, PETE LAWRENCE

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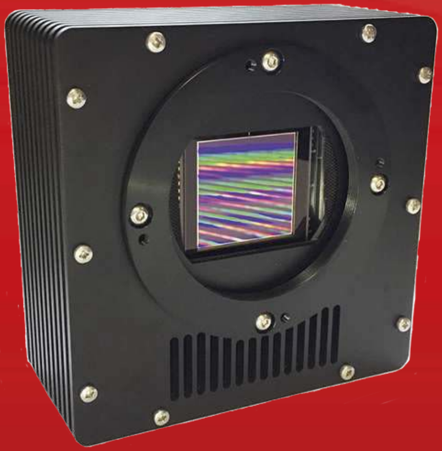

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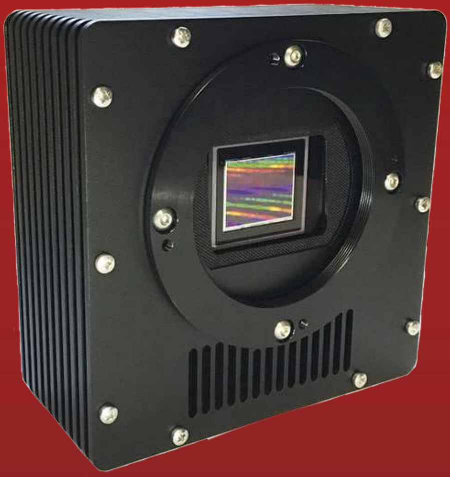

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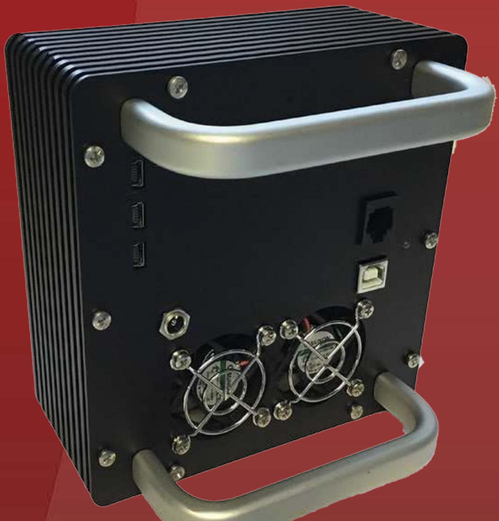


For further information, please take a look at

www.sxccd.com

See an interactive 360° model of this mount at
www.skyatnightmagazine.com/skyguipro

iOptron SkyGuider Pro tracking mount

A revised variant of a popular camera mount with plenty of surprises

WORDS: PAUL MONEY

VITAL STATS

- **Price** £449
- **Latitude adjustment** –30° to 65°
- **Tracking rates** Sidereal, half-sidereal, lunar and solar, for both hemispheres
- **Polarscope** Illuminated with 6° field of view
- **Power** Internal rechargeable Li-Poly battery, 3.7V, 2000mAh
- **Extras** Vixen-type dovetail, dec. mounting block & bracket, 1.35kg counterweight plus shaft, mini USB cable, soft case
- **Weight** 1.45kg without counterweight and shaft
- **Supplier** Altair Astro
- **www.**altairastro.com
- **Tel** 01263 731505

SKY SAYS...
The SkyGuider Pro's adjustable altaz base is detachable – a new feature of this variant of the mount

Camera tracking mounts have exploded in popularity over the past few years, a trend iOptron has been at the forefront of. This variant is a fresh look at the original SkyGuider, which we reviewed in our July 2014 issue.

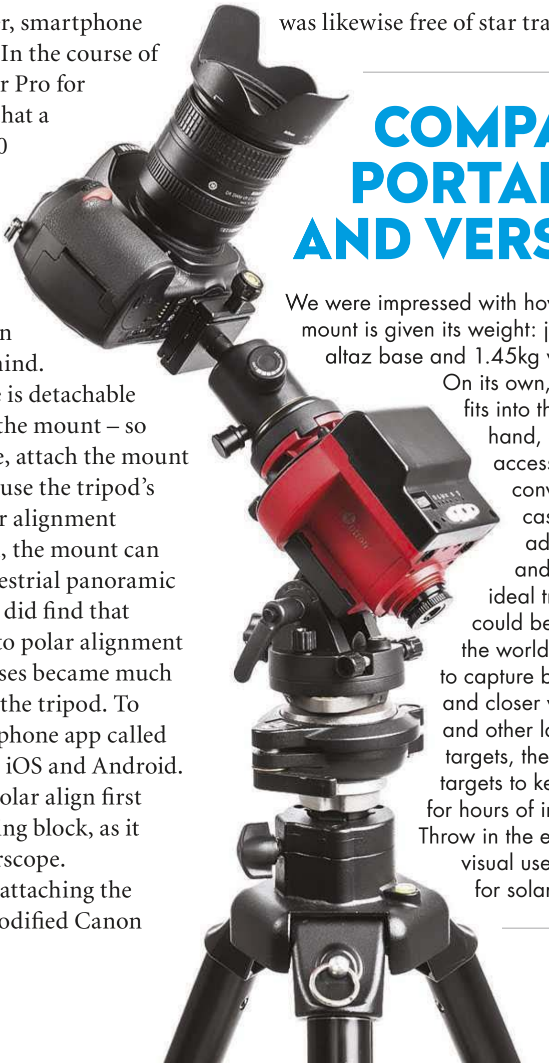
The SkyGuider Pro is supplied in a soft padded case, along with a dec. camera mounting block, a dec. mounting bracket with camera-mounting disc, an integrated illuminated polarscope, a 1.35kg counterweight and counterweight shaft, and a Vixen-type dovetail saddle. You'll also find a micro USB charging cable and a clearly written manual in the box. Power comes from an internal Li-Poly 3.7V, 2000mAh battery that can be recharged by using the supplied micro USB cable when the mount is connected to a computer, smartphone charger or portable battery pack. In the course of our review we used the SkyGuider Pro for around 12 hours; iOptron states that a single charge can provide up to 20 hours of use in ideal conditions.

A slew of choices

Assembly was quick and straightforward, though you do have several options depending on the sort of imaging you have in mind. The mount's adjustable altaz base is detachable – a new feature of this variant of the mount – so you could simply remove the base, attach the mount directly to a standard tripod and use the tripod's own pan/tilt mechanism for polar alignment adjustment. In this configuration, the mount can also be used for slow-motion terrestrial panoramic photography. That being said, we did find that making the sorts of adjustments to polar alignment you need for astronomical purposes became much easier by adding the altaz base to the tripod. To aid with this there is a free smartphone app called iOptron Polar Scope available for iOS and Android. In this configuration, you must polar align first before adding the camera mounting block, as it covers the view through the polarscope.

We tested this second setup by attaching the mount, ball head and our own modified Canon EOS 300D DSLR with a 16mm wide-angle lens, and taking test exposures of the Milky Way in Cygnus and Lyra lasting for five, 10 and 20 minutes. The light summer sky meant we had to stop the last exposure down to f/11, but the stars were pinpoint and not trailed on close examination. Swapping to a 70-300mm lens set to 70mm and f/5.6, we took a five-minute exposure of the Cygnus region. Again, there was no star trailing.

If you want to use a heavy lens on your camera, you may need to remove the ball head and mounting block, swapping them for the dec. mounting bracket and counterweight to achieve balance. In this configuration we took one-minute exposures of the star cluster M11 with the same DSLR and a 100-400mm lens set at 400mm. The image was likewise free of star trails. ▸



COMPACT, PORTABLE AND VERSATILE

We were impressed with how sturdy the camera mount is given its weight: just 1kg without the altaz base and 1.45kg with it attached. On its own, the camera mount fits into the palm of your hand, and along with its accessories fits into a convenient padded case. You only need to add your camera gear and tripod to create an ideal travelling system that could be taken anywhere in the world. Offering the ability to capture both wide star fields, and closer views of nebulae and other large deep-sky targets, there are plenty of targets to keep this system busy for hours of imaging at a time. Throw in the excellent tracking for visual use and it also has use for solar eclipse chasing.

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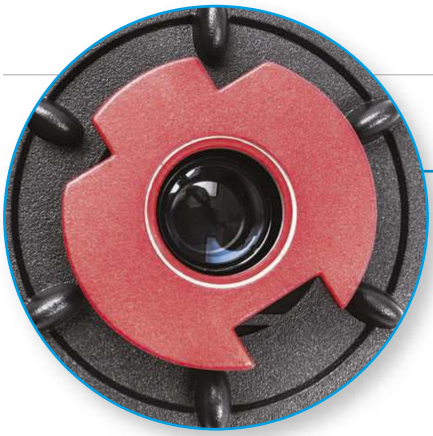
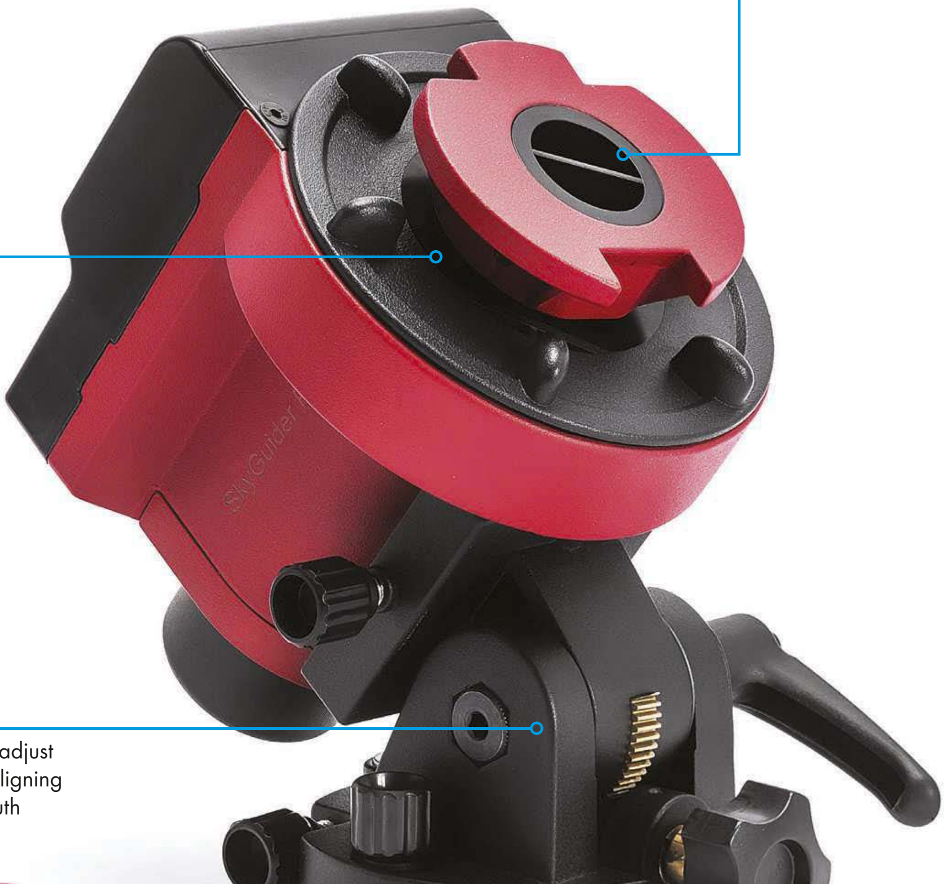
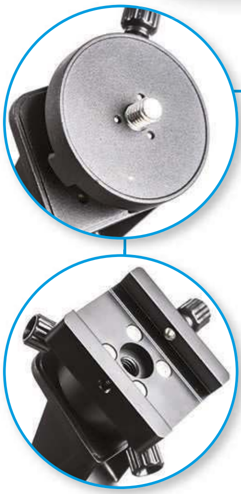


POLARSCOPE

The in-built illuminated polarscope is perfect for getting good alignment. Its adjustable illuminated reticule can be used for both northern and southern hemispheres, ideal if you want to take the mount on holiday.



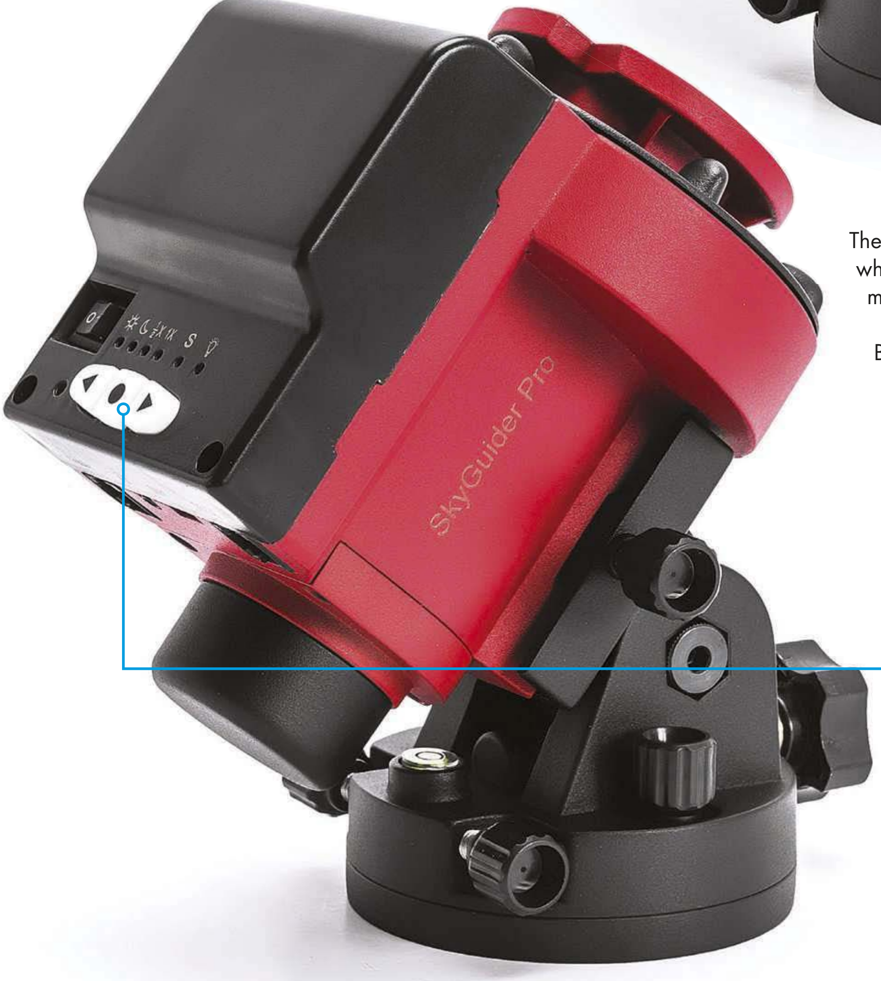


ADAPTABLE HEADS

The SkyGuider Pro comes with adaptors for simple wide-field imaging (top left), cameras with heavier lenses (bottom left) and even small scopes via the Vixen-style adaptor (right). You can also add a second mounting disc to the base of the dec. mounting bracket for dual imaging.

ALTAZ BASE

The altaz base is sturdily constructed and is easy to adjust with its fine latitude adjustment control, even while aligning to Polaris using the polarscope. There are two azimuth adjustments and a bubble level to help level to unit.



SWITCHES AND GUIDE PORT

The rubber switches include forward/backwards slewing, while the centre button allows you to select the operating mode. These are solar, lunar, sidereal and half-sidereal, as well as northern/southern hemisphere tracking. Below these are the ST-4 and camera control ports, the USB port for recharging the battery and an HBX port for connecting a hand controller.

FIRST LIGHT

▲ A wide-field view of the Milky Way, a single 20-minute exposure at ISO 400 and f/11, taken with a modified Canon EOS 300D DSLR

▲ A stack of eight one-minute exposures of star cluster M11, captured with the same camera at ISO 400 and f/5.6

SKY SAYS...

Now add these:

1. Sturdy photo tripod
2. iOptron SkyTracker ball head
3. iOptron Go2Nova 8408 hand controller

▸ The camera mount has a port for attaching a Go2Nova 8408 hand controller, but this was not available at the time of the review. There is also an ST-4 autoguiding port, though you should bear in mind that it can only guide in RA as there is no dec. motor. However, for our tests we were very pleased with the general tracking without either, as it works so well.

If you were to purchase a second camera mounting disc, you could attach it to the base of the dec. mounting bracket and add another camera – perhaps for meteor shower photography. That way you can cover double the area of sky and track too. It's also worth noting that this mount has uses beyond astrophotography: using the dovetail saddle, we attached a solar telescope to catch a glimpse of the Sun and later a 3-inch refractor to show one of our neighbours a wide-field view of Jupiter and its moons. It is a great piece of kit and highly recommended. Ⓢ

VERDICT

ASSEMBLY	★★★★⯪
BUILD AND DESIGN	★★★★⯪
EASE OF USE	★★★★☆
FEATURES	★★★★☆
TRACKING ACCURACY	★★★★★
OVERALL	★★★★⯪

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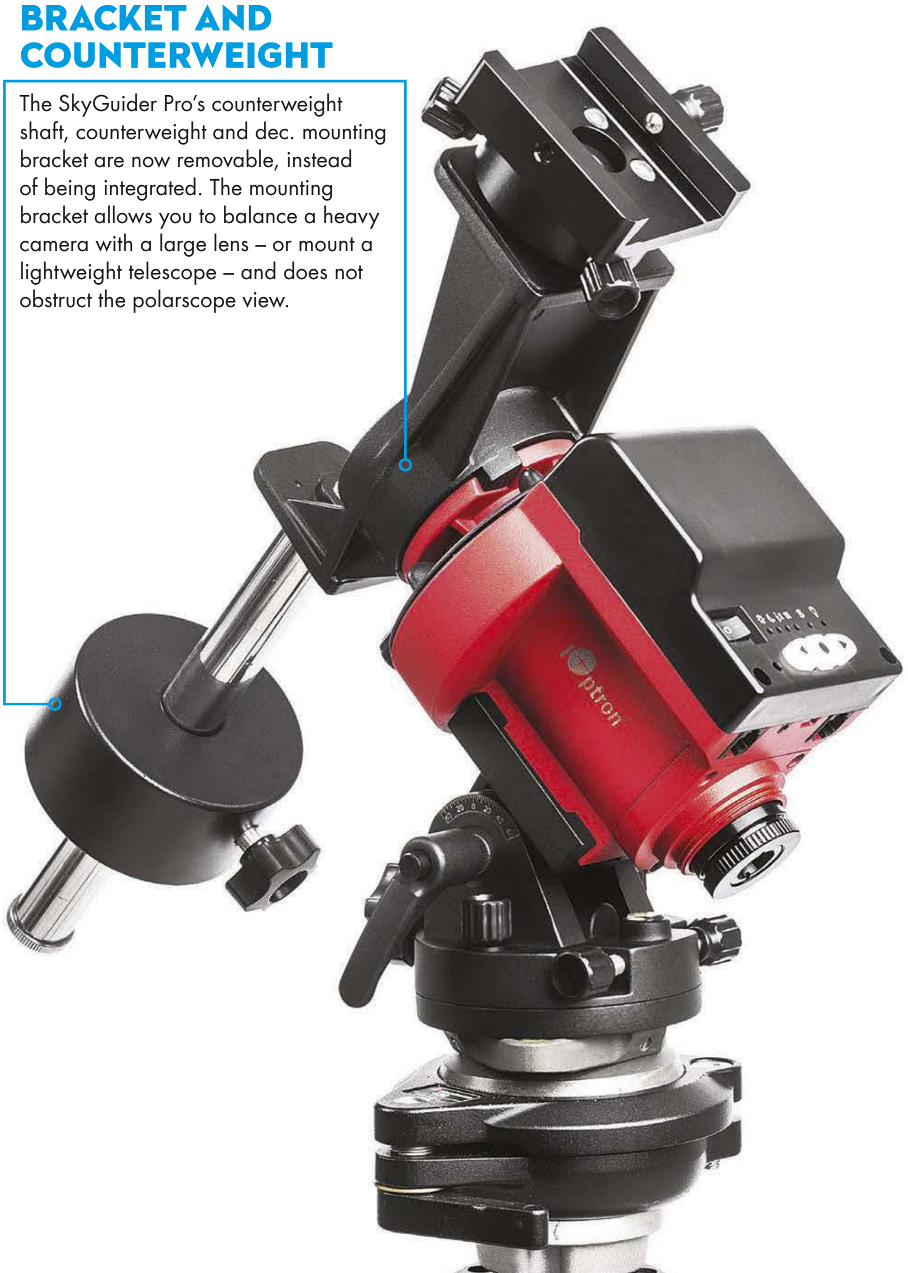
BRACKET AND COUNTERWEIGHT

The SkyGuider Pro's counterweight shaft, counterweight and dec. mounting bracket are now removable, instead of being integrated. The mounting bracket allows you to balance a heavy camera with a large lens – or mount a lightweight telescope – and does not obstruct the polarscope view.



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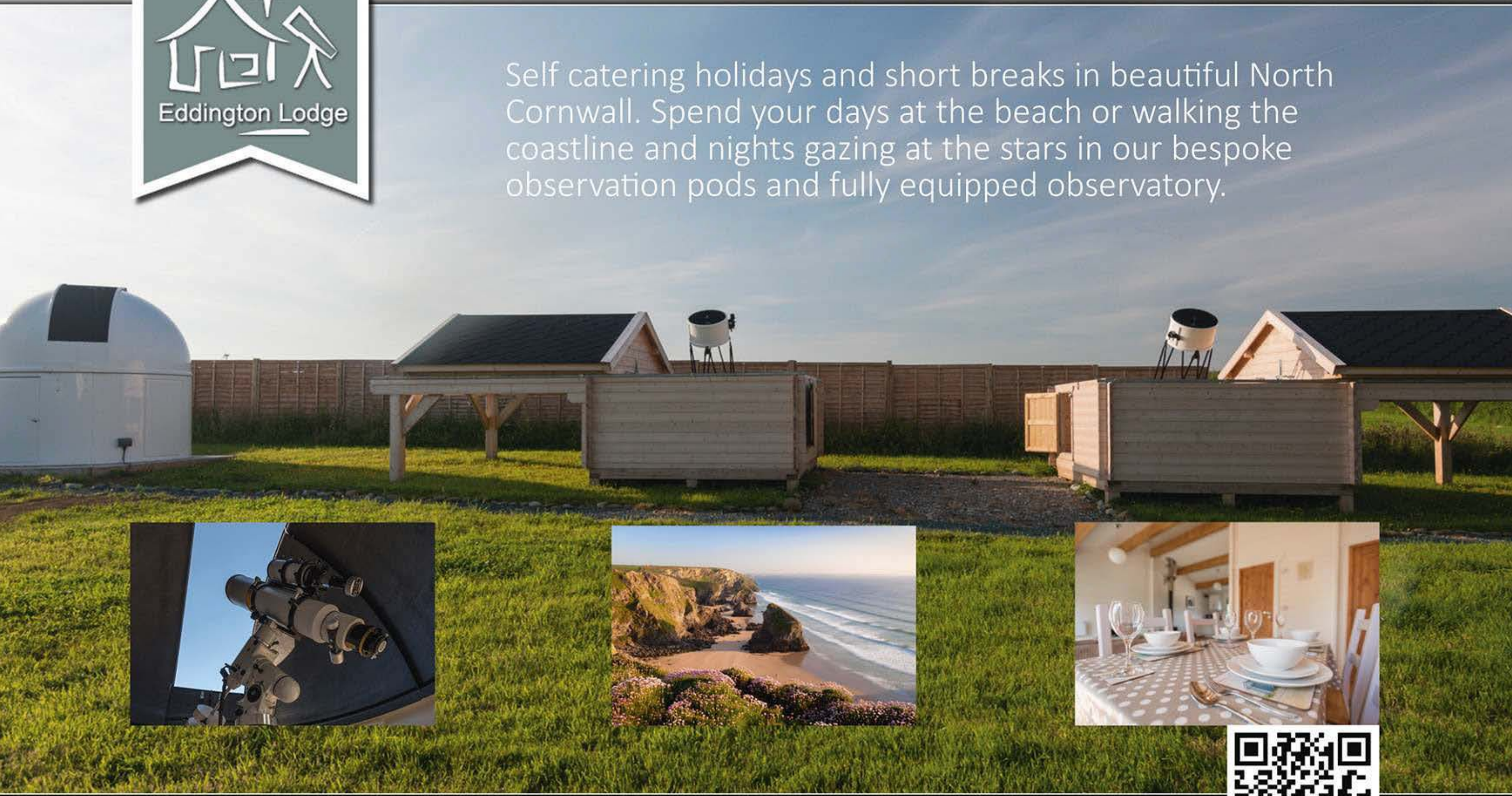

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FIRST **LIGHT**

See an interactive 360° model of this camera at
www.skyatnightmagazine.com/qhy367c

QHYCCD QHY367C CMOS colour camera

A well-cooled one-shot camera with excellent sensitivity

WORDS: PETER JENKINS

VITAL STATS

- **Price** £4,199
- **Sensor** Sony IMX094 CMOS
- **Pixels** 7,376x4938 (4.88μm square)
- **Resolution** 36.4 megapixels
- **Exposure range** 60 microseconds to 60 minutes
- **Read Noise** 2.4e at unity gain
- **Dimensions** 90mm diameter, 110mm long
- **Power** 12V power adaptor 3.5A
- **Weight** 788g
- **Extras** USB 3.0 cable, power cable, 2-inch nosepiece, angle adjustment ring
- **Supplier** Modern Astronomy
- **www.** modernastronomy.com
- **Tel** 020 8763 9953

WWW.THESECRETSTUDIO.NET X 6

QHY's latest one-shot-colour camera, the QHY367C, is a high-resolution CMOS device capable of Solar System imaging but primarily intended for deep-sky astrophotography.

The camera uses Sony's IMX094, one of the highest-resolution full frame (36x24mm) colour sensors available, to create an instrument that QHY dubs a 'COLDMOS'. The sensor is cooled by a two-stage TEC (Peltier cooling system), which provides cooling of up to 35° below the ambient temperature. This results in low noise and a huge 14 stops of dynamic range. Both the sensor glass and the glass for the optical window have anti-dew heating, which works exceptionally well and is particularly useful when humidity is high.

The resulting RAW file size of an individual exposure is almost 71MB, which means the camera's USB 3.0 connection is a welcome one (a USB 3.0 cable is included), providing extremely short download times; in our case, quicker than two seconds for each full frame capture. The 128MB DDRII image buffer acts as a cache to insure against frame loss, especially useful when shooting videos for planetary imaging. Of course, this all means you need a powerful computer to process such large files, and one with a USB 3.0 port.

The QHY367C uses a rolling shutter design, allowing exposures as short as 60 microseconds and as long as 60 minutes. It is capable of recording 3.2 frames per second at full resolution. Reduce the resolution by selecting a 'region of interest' and you can increase the frame rate up to 83 frames per second.

SKY SAYS...
A versatile one-shot-colour camera that pushes the boundaries of definition and sensitivity

Optional streaming

There is no physical manual in the box, nor any software; both are available as downloads from QHY's website. QHY provides both EZCap and SharpCap for camera control and image capture, as well as the necessary drivers. ASCOM drivers are available if you want to connect the camera to other capture software, such as MaxIm DL or Sequence Generator Pro. SharpCap can be used to enable a live video feed from the camera for capture or even for live broadcast. The live broadcast feature may be useful for members of astronomy societies who want to share the views through their scope either live or as a webcast.

The camera is supplied with an M54 to 2-inch adaptor and an angle adjustment ring. Other adaptors will be available, including one to fit Canon or Nikon lenses for wide field views. A 2-inch infrared-cut filter is recommended for planetary work; it was not available to us at the time of the review, but can be supplied as an optional extra.

The QHY367C is simple to use. Attach it to a 2-inch drawtube, then connect a 12V power ▸

SONY IMX094 CMOS CHIP

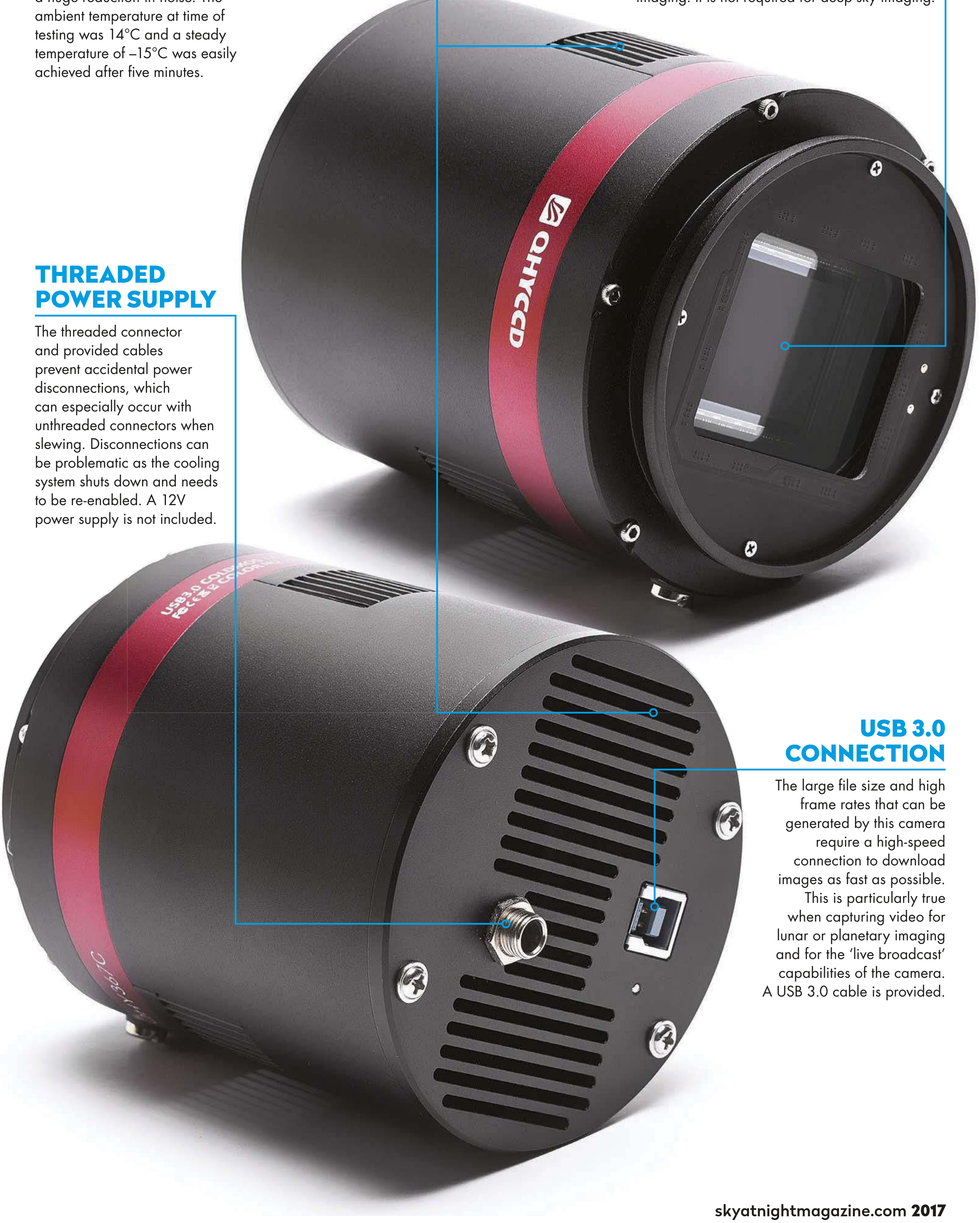
The full frame Sony IMX094 chip has an impressive resolution of 36.4 megapixels. It measures 36x24mm, providing a 7,376x4,938 pixel array where each pixel is 4.88x4.88μm. Extremely low noise can be achieved when the sensor is cooled by the two-stage TEC (Peltier cooling system). Image captures can be 'binned' at 2x2 to further increase sensitivity. One thing to bear in mind is its large diagonal (43mm). You need to ensure that the image circle provided by your telescope provides adequate coverage, particularly if you are using a flattener/reducer, otherwise vignetting may occur. Many telescopes are available that provide a large enough image circle so check when buying this camera that your intended scope and field flattener/reducer (if you use one) provide a large enough light cone.

PELTIER COOLING

The two-stage Peltier cooling system can reduce the operating temperature to 35° below the ambient temperature, providing a huge reduction in noise. The ambient temperature at time of testing was 14°C and a steady temperature of –15°C was easily achieved after five minutes.

ANTI-GLARE COATINGS

There are anti-reflection coatings on both sides of the optical window over the sensor, and this helps prevent star haloes. Note that the window does not have an infrared-cut coating, so a separate 2-inch screw-in filter is recommended for Solar System imaging. It is not required for deep-sky imaging.



THREADED POWER SUPPLY

The threaded connector and provided cables prevent accidental power disconnections, which can especially occur with unthreaded connectors when slewing. Disconnections can be problematic as the cooling system shuts down and needs to be re-enabled. A 12V power supply is not included.

USB 3.0 CONNECTION

The large file size and high frame rates that can be generated by this camera require a high-speed connection to download images as fast as possible. This is particularly true when capturing video for lunar or planetary imaging and for the 'live broadcast' capabilities of the camera. A USB 3.0 cable is provided.

FIRST LIGHT

SKY SAYS...
Now add these:

1. Astronomik 2-inch infrared-block filter
2. QHYOAG-M off-axis guider
3. QHY5L-II monochrome camera kit

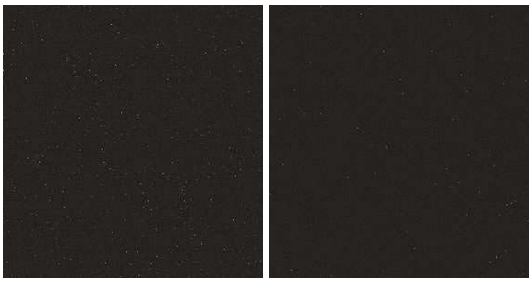
▸ supply and the USB 3.0 cable. These are the only two ports on the camera – there is no guide port, so an external guide system is required for longer exposures.

After fixing it to our own 4.5-inch reflector, we selected M13 in Hercules as our first target and quickly found that our regular flattener/reducer produced serious vignetting. It did not provide a large enough image circle to cover such a large chip. Once removed, the remaining vignetting was easily dealt with by calibrating with flat frames. Without the reducer, the scope was working at f/7, so we were surprised that a two-minute exposure seemed to be longer than required. Cutting the exposure time to one minute we took 24 images of M13. Our cropped frame of the final stacked image – showing only 10 per cent of the original frame area – showed superb detail, including the propeller feature.

Encouraged by this, we moved to the Iris Nebula in Cepheus and captured 30 two-minute exposures. Although somewhat noisy (more frames would be needed to clean this up) the result was surprising in that it even revealed some of the dust surrounding the nebula. QHY has, with the 367C, produced an outstanding and versatile one-shot-colour camera that pushes the boundaries of definition and sensitivity for deep space astrophotography. Ⓢ

VERDICT

BUILD AND DESIGN	★★★★½
EASE OF USE	★★★★½
FEATURES	★★★★★
IMAGING QUALITY	★★★★½
OPTICS	★★★★★
OVERALL	★★★★½



▲ The difference cooling makes can be seen in the noise of dark frames taken with cooling system off (left, ambient temperature) and on (right, 30° below ambient)

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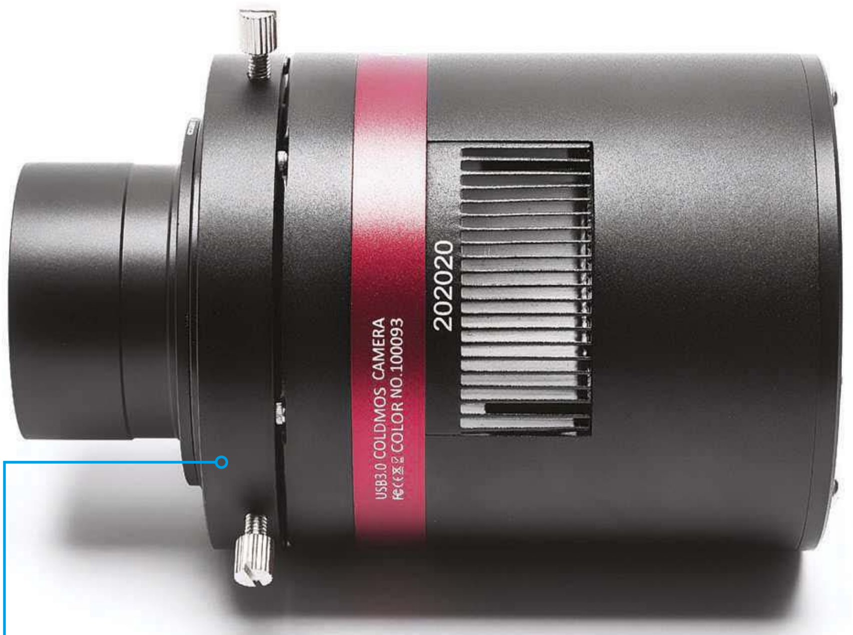
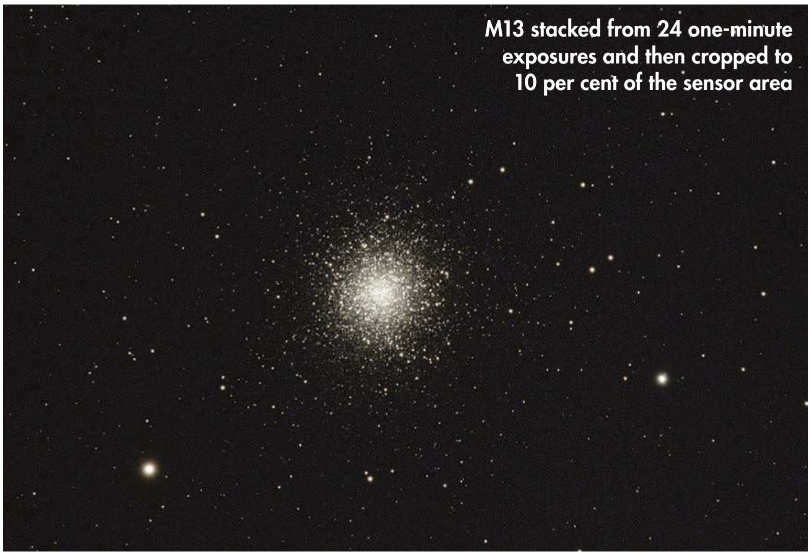
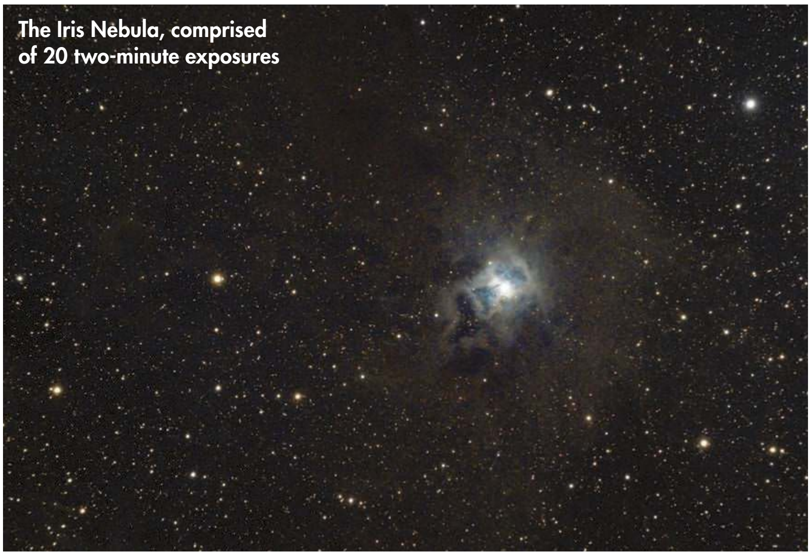


TELESCOPE CONNECTION & ADJUSTMENT RING

The M54 to 2-inch screw-threaded adaptor/nosepiece allows the camera to be easily inserted into a 2-inch focuser. There is an M48 thread on the nosepiece so you can attach a filter. The angle adjustment ring allows you to get the sensor precisely square to the image plane.



M13 stacked from 24 one-minute exposures and then cropped to 10 per cent of the sensor area



The Iris Nebula, comprised of 20 two-minute exposures

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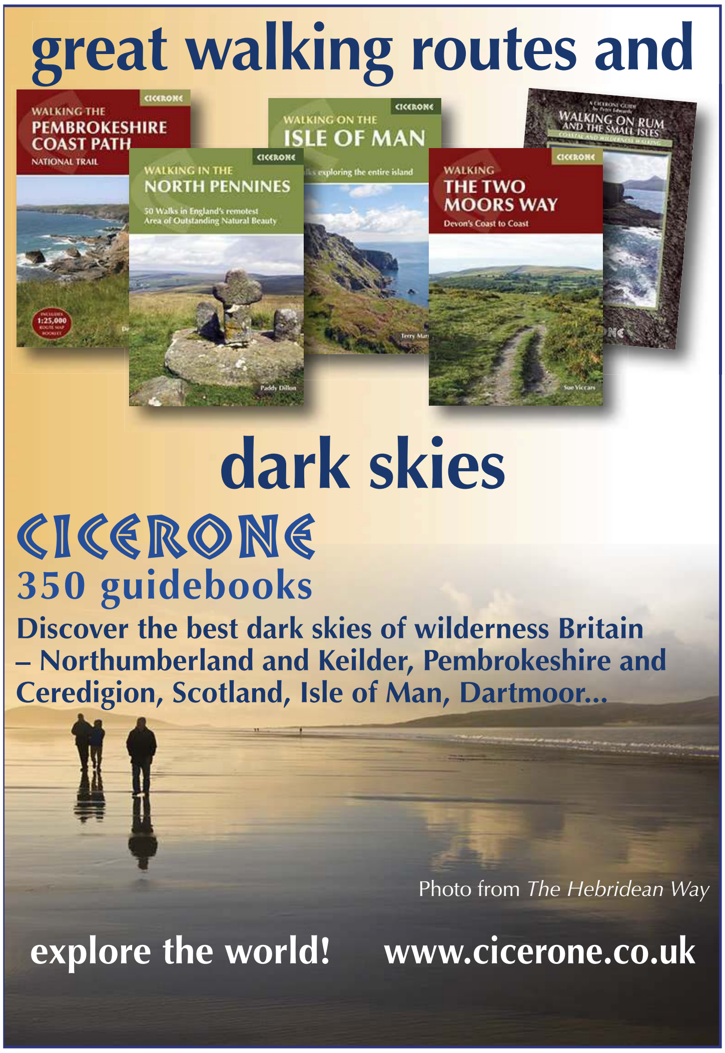

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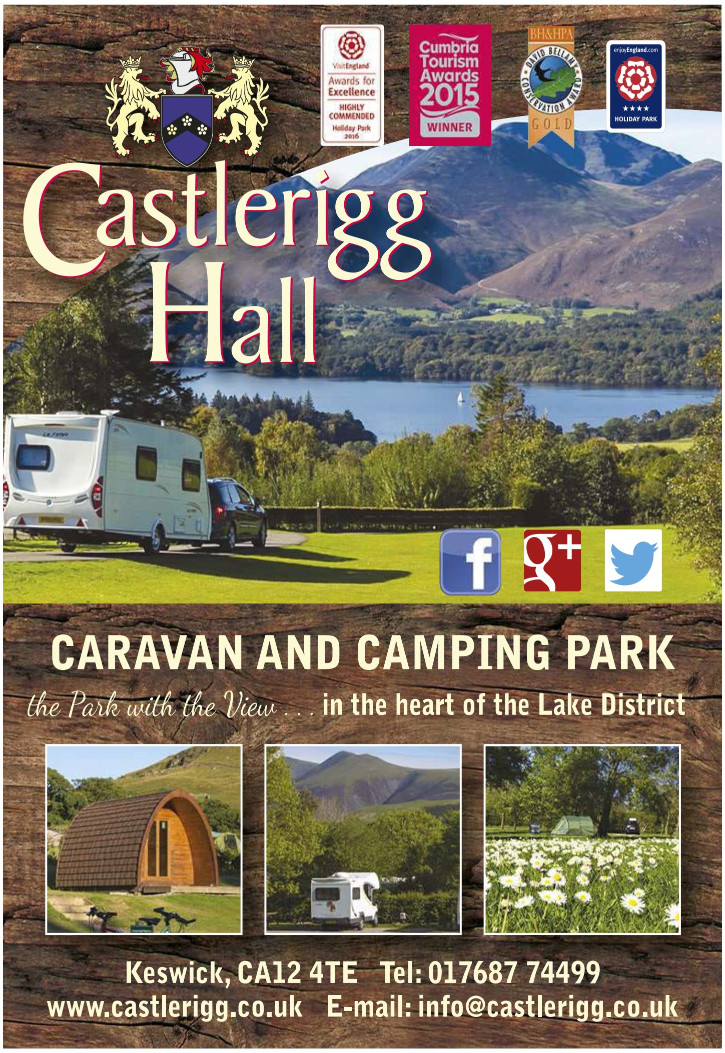

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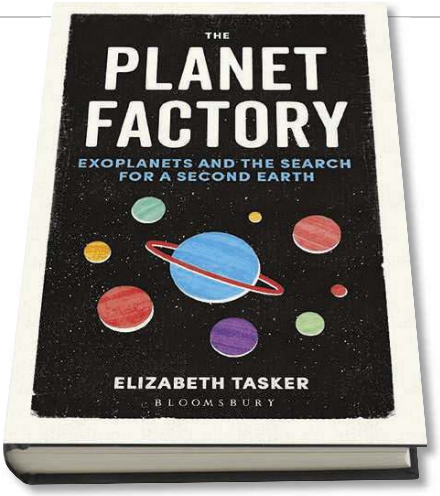
Books

New astronomy and space titles reviewed

RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

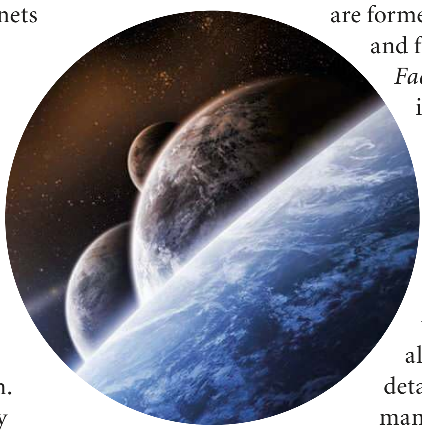


The Planet Factory

Exoplanets and the search for a second Earth

Elizabeth Tasker
Bloomsbury Sigma
£16.99 ● HB

There's an old Indian fable called 'The Blind Man and the Elephant', in which six blind men examine an elephant. One finds the smooth membrane of the elephant's ear, the other a carved tusk. Another grasps the tail. Each is correct and yet none has properly described the elephant. The same can be said of the current state of play in astronomy and the rapidly growing field of exoplanet research: with more than 4,600 exoplanets detected (and counting) since 2002, are we any closer to seeing the Universe for what it truly is, or are we blindly making conclusions based on a series of observations? That is the premise of this book, which attempts to summarise this vast field of research.



We're detecting more and more exoplanets, but the big picture eludes us

ISTOCK

Starting with the early Universe and the building blocks that were necessary for planet formation, Elizabeth Tasker chronicles the exoplanetary detection methods of the past, and new techniques currently applied for more rapid and accurate detection, the success of the Kepler space telescope in advancing the discovery of exoplanets in the 'Goldilocks zone' (not too far and not too near from the star) that could potentially support life with water and atmospheres similar to Earth, and the possibility of the existence of other life forms. Tasker clearly knows her field very well, sharing stories of the countless discoveries of exoplanets in the past 20 years, starting in 1995 with 51 Pegasi b.

Detailing all the ingredients necessary for stable planetary systems, how they are formed, their structures and features, *The Planet Factory* is packed with interesting insights and scientific content that capably captures the current state of exoplanet research.

However, it does feel repetitive at times and there is almost an overload of detail. We leave with many new observations that collectively support the argument that planetary systems exist around pretty much every star, but the bigger question of our place in the Universe and how it all weaves together remains unsolved. In this relatively new field of astronomy, we are still blind to that one.
★★★☆☆

NIAMH SHAW *is an engineer and space science communicator*

TWO MINUTES WITH
Elizabeth Tasker

What can the study of other planetary systems tell us about our Solar System?
One example is planet migration, where a young planet changes its orbit to be closer or farther from the star. This was known about since the 1980s, but our Solar System showed little evidence of it happening. It was assumed that migration was not important in shaping a planetary system. This changed with the discovery of exoplanets, which commonly show strong evidence of major rearrangements. The question then became "Why didn't our planets move more?", with an answer that may lie in Jupiter and Saturn anchoring one another.

What are some of the strangest exoplanets we have discovered so far?
The first discovered were some of the strangest. Huge hot Jupiters should not be able to form so close to their star, so how did they get there? Or the planets around the dead corpses of stars known as pulsars: did they form when the pulsar was a regular star, or are they the grizzly rebirth of a star that the pulsar ripped into pieces?

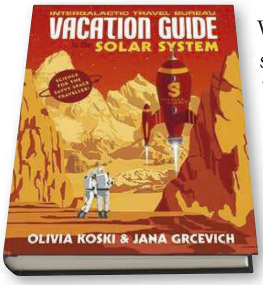
Which is your favourite?
It might be 55 Cancri e. It is about twice the size of Earth, with an orbit lasting just 18 hours. It could be a highly volcanic lava world covered in molten magma, or with an ocean consisting of a strange state of water that is neither liquid nor gas. It could even have a mantle of diamond and seas of tar.

ELIZABETH TASKER *is an astrophysicist and an associate professor at the Japanese Aerospace Exploration Agency*

Vacation Guide to the Solar System

BOOK OF THE MONTH

Olivia Koski and Jana Grcevich
Square Peg
£12.99 ● PB


INTERGALACTIC TRAVEL BUREAU
VACATION GUIDE to the SOLAR SYSTEM
OLIVIA KOSKI & JANA GRCEVICH

Would you like to ski on Pluto? Tour the blistering surface of Venus in a giant submarine on wheels? What about plunging into the subsurface, briny ocean of Europa? Look no further than this lavishly illustrated tome and you'll find out how to do all of this – and more.

Vacation Guide to the Solar System reads like an actual travel guide. However, the destinations are far more exotic than anything on this overpopulated and polluted Earth. This is a study of the Solar System at its most majestic; a blow-by-blow account of all of the major planets, selected dwarf planets, and some of the more substantial or interesting moons, and always with a focus on what to see and do in these amazing, alien environments.

We first get briefed on what to pack, what to expect in different gravities – including artificial – choosing a spacesuit and how to not die as you are exposed to radiation that could cook a steak in nanoseconds. Then the fun starts. After a visit to the Moon, we reach sunwards to find Mercury, before heading outwards, stopping at every planet along the way until we reach Pluto and beyond.

Each chapter is broken down into sections detailing how to get there, when to go, what to do, getting around, and so on – like a regular travel guide, with an emphasis on scientific accuracy. But what really brings this book alive are the stunning illustrations, all done in an art-deco style, like the travel posters of yesteryear. My only quibble is the persistent and frustrating use of Fahrenheit. But still, superb.

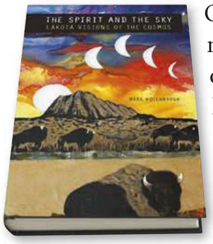
★★★★★

MARK GARLICK *is an illustrator, author and computer animator whose work graces our Exoplanet Excursions column*

The Spirit and the Sky

Lakota Visions of the Cosmos

Mark Hollabaugh
University of Nebraska Press
£41 ● HB



Our perspective of the night sky is shaped by our culture and our knowledge of science. Science has unveiled the secrets of meteor showers, eclipses and aurorae, but to some cultures throughout history these spectacles often had a spiritual meaning.

In *The Spirit and the Sky*, Mark Hollabaugh investigates how the Native American Lakota people might have interpreted the night sky in the 19th century. Understanding how they viewed astronomy is surprisingly difficult. The Lakota had no written language at the time, and much of what is known comes from the often biased accounts produced by the American settlers. Despite this, Hollabaugh brings together all of what is known about Lakota astronomy. Of particular interest are the Lakota "winter counts". The people measured winters instead of years, and every winter each tribe would draw an image that best represented that year. Celestial phenomena were clearly of importance to them, as the winter counts show the 1833 Leonid meteor storm, as well as solar and lunar eclipses from that century. These have the added importance of helping to synchronise the winter counts with our own calendar.

It does seem apparent that celestial objects played a part in the Lakota spiritual beliefs – for instance they had their own names for the stars and constellations – but some of the connections made in the book do seem quite vague. It is also obviously quite a niche subject, which can make it difficult to appreciate, although it may still intrigue those with an interest in the history of astronomy.

★★★☆☆

AMANDA DOYLE *is a freelance science writer and a postdoctoral researcher at the University of Warwick*

The Earth Gazers

Christopher Potter
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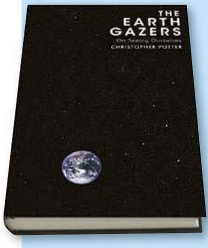


The Earth Gazers tells the story of the Space Race from a more personal perspective, rather than a solely technical one. It considers the long-lasting effect on those who saw Earth from such a detached vantage point, both in person and from the many iconic images returned home.

The book opens with Charles Lindbergh and his historic transatlantic flight, and takes us through the development of rocket flight, both in the US and the USSR, up until the final manned lunar landing. From rocket pioneer Robert Goddard in the US to the advancements made by Germany during World War II – and how that went on to influence both sides of the Iron Curtain – it's a very human story.

Despite this refreshing take on the material, the book is sadly spoiled by numerous factual errors. The author states that by the end of the 14-day Gemini VII flight, the crew "had been in space more than twice the length of any of the future Apollo missions", which lasted up to 13 days. He wrongly describes Gemini as having a launch escape system similar to that found on Mercury and Apollo, rather than the ejector seats that were actually used. Apollo 15, rather than Apollo 17, is said to be the mission that spent the longest time on the lunar surface, and so the errors continue.

It's a great shame that these errors weren't spotted as the book is otherwise well written and takes a different, more personal viewpoint than many others on the subject.

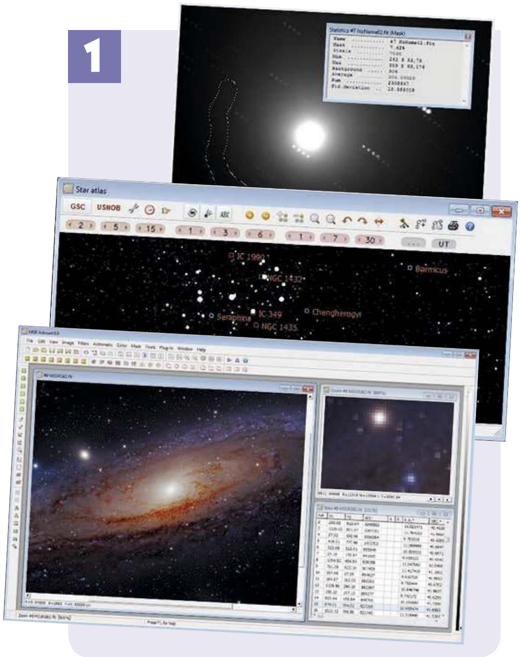
★★☆☆☆

MARK BOWYER *is an expert in the US manned space programme*

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

1



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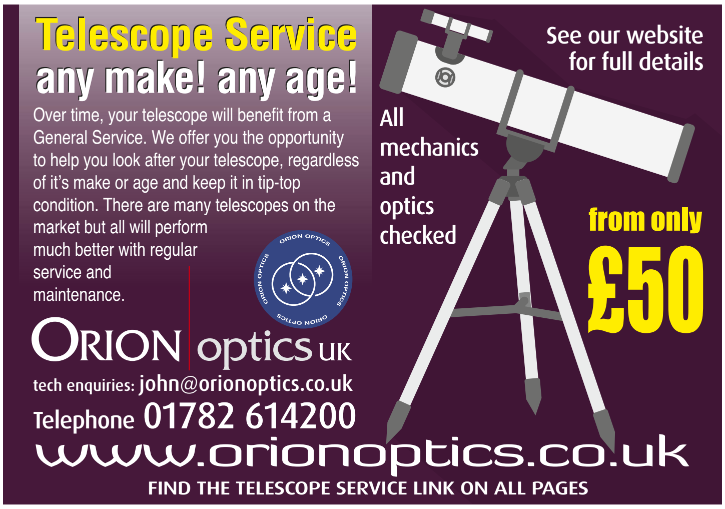

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WHAT I REALLY WANT TO KNOW IS...

Where does antimatter come from?

Dr Roland Crocker has been on a quest to discover what produces anitmatter particles called positrons in our Galaxy

INTERVIEWED BY PAUL SUTHERLAND

It has been known since the 1930s that antimatter exists alongside ordinary matter in the Universe. It was first discovered in cosmic rays from deep space – but where does it come from? I've been trying to find out.

For every elementary particle, there's an antimatter particle with an opposite quantum state. So for the electron, which has a negative charge, there's an antimatter particle, called a positron, with a positive charge. Positrons are the dominant component of antimatter in our Galaxy. We use them medically in PET scanning – positron emission tomography.

When an antimatter particle encounters its ordinary-matter partner, they annihilate each other. However, ordinary matter greatly outweighs antimatter in the Universe, by many orders of magnitude. We also can't detect positrons in the Galaxy directly; we infer their existence from the gamma-ray signal emitted when they collide with electrons in the interstellar medium.

Something strange is going on

The first instruments capable of detecting gamma rays were attached to high-altitude balloons in the early 1970s and later launched on satellites. Even those early experiments indicated that the centre of the Galaxy was quite bright in gamma rays produced by annihilating electrons and positrons.

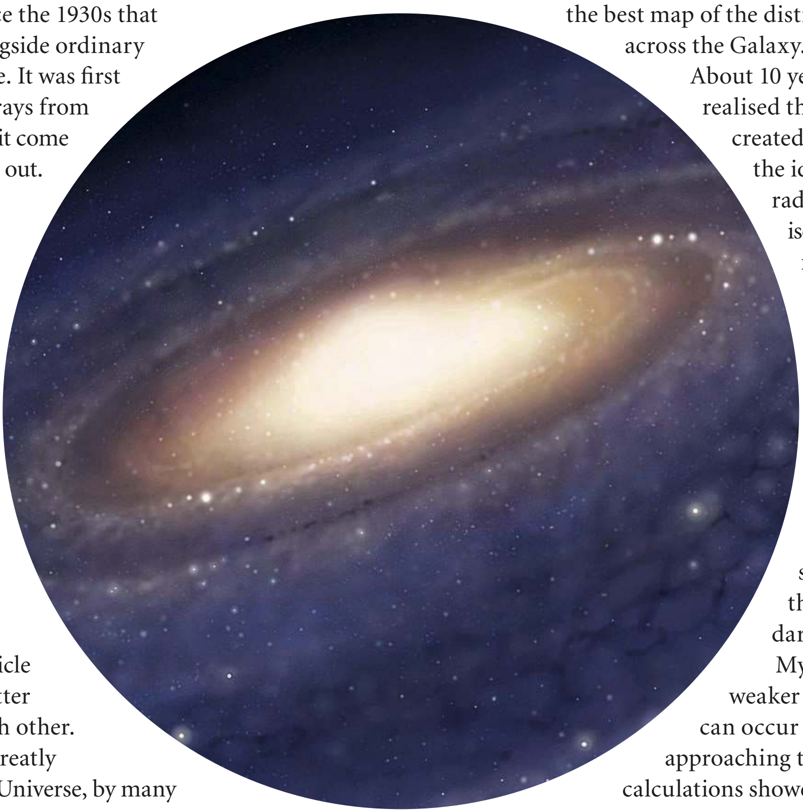
Over subsequent decades, the quality of instrumentation improved. It became clear that the central bulge of the Galaxy is producing a lot of positrons. This seemed odd because the bulge is made up of ancient stars that are about 10 billion years old. You wouldn't expect much to be happening there. In all other wavelengths, the bulge is quite dim, but in gamma rays it's about as bright as the rest of the Galaxy. We've been investigating using data gathered by ESA's Integral space telescope, which has produced the best map of the distribution of gamma rays across the Galaxy.

About 10 years ago, astronomers realised that positrons were being created at low energies, supporting the idea that they come from the radioactive decay of unstable isotopes. One isotope, nickel-56, is produced copiously in Type Ia supernovae, where a white dwarf star becomes too massive and destroys itself. But that explanation doesn't solve our problem. Those supernovae don't occur in stars as old as those in the Galaxy's bulge. We also ruled out the supermassive black hole at the heart of the Galaxy and dark matter as possible causes.

My team looked for a weaker type of supernova that can occur in older stellar populations approaching the age of the bulge. Our calculations showed that a good candidate would be a binary system with two fairly low-mass stars that are exchanging material. Each star isn't that massive – more massive than the Sun but less than two times its mass. Because they're fairly low-mass stars, they have long lifetimes. You end up with two white dwarfs. One will be a helium white dwarf, because it's not massive enough to undergo helium burning in its core, and the other is a carbon-oxygen white dwarf.

Eventually, the helium white dwarf gets so close to its more massive companion that it's disrupted by its tidal field. The two stars merge into a single object with carbon and oxygen at its centre and an unstable shell of helium, ready to explode. It produces an unusual type of supernova, a much fainter subclass of a Type Ia supernova. The explosion produces another type of radioisotope, called titanium-44, which is also a positron source.

This looks to be the answer because the process can explain about 90 per cent of the antimatter in the Galaxy. It neatly explains both where the positrons are being created and the number that are being created too.



An unusual type of 'dim' supernova seen in old stellar populations may explain the origin of most of the antimatter detected in our Galaxy

MARK GARLICK

ABOUT ROLAND CROCKER
Dr Roland Crocker studies high-energy astrophysics, cosmic rays and galactic astronomy at the Australian National University's College of Physical and Mathematical Sciences, in Canberra.

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THE SOUTHERN HEMISPHERE IN SEPTEMBER

With Glenn Dawes

WHEN TO USE THIS CHART

1 SEP AT 00:00 UT
15 SEP AT 23:00 UT
30 SEP AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

SEPTEMBER HIGHLIGHTS

The crescent Moon next to a bright planet is always an attractive sight. This month sees close conjunctions with both Venus and Jupiter. On the 18th radiant Venus is only 2° from the 27-day-old Moon in the dawn sky. Look low in the east-northeast 50 minutes before sunrise (around 05:00 EST). The Jovian meeting has to wait until after New Moon. On the 22nd the two-day-old Moon is 4° to the lower right of Jupiter, close to the western horizon one hour after sunset.

STARS AND CONSTELLATIONS

Aquarius, the Water Bearer, is one of the oldest constellations. From Down Under it is below bright Fomalhaut (Alpha (α) Piscis Austrini) in the northern evening sky in September. Its mythology shows a human figure pouring water from a jar. Its many faint stars make it virtually invisible under suburban skies, its two 'stand outs' both being mag. +2.9: Sadalmelik (Alpha (α) Aquarii) and Sadalsuud (Beta (β) Aquarii). These Arabic names are associated with luck when wishing for good rainfall.

THE PLANETS

The early evening is the last chance to glimpse Jupiter before it is lost in the western twilight. After this, try looking high in the northwest for Saturn. It is soon an evening-only planet, setting by midnight at month's end. Neptune and Uranus are well placed to observe, transiting around 23:00 EST and 02:00 EST respectively mid month. Brilliant Venus is now only visible low in the eastern dawn. Mars rises slowly out of the Sun's glow, and at the close of September is only 3° from Venus.

DEEP-SKY OBJECTS

In Aquila, close to its border with Serpens, is open cluster NGC 6755 (RA 19h 07.8m, dec. +4° 16'). It has an unusual appearance, as it heavily obscured by gas and dust. The cluster shows the stars in clumps with a dark lane in its northern half. The brightest stars are 10th-magnitude and the cluster is 14 arcminutes across.

Moving 3.3° south-southeast you'll find the globular cluster NGC 6760 (RA 19h 11.2m, dec. +1° 02'; pictured). This is a challenge: being quite small (2 arcminutes in diameter) it is easy to miss. The globular has a broad core only slightly brighter than its thin halo. It takes serious aperture to resolve into individual stars. Even 12-inch instruments will not succeed, showing instead some mottling in what is otherwise a round, mag. +8.8 fuzzy patch.

CHART KEY

GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
COMET TRACK
ASTEROID TRACK
METEOR RADIANT
QUASAR
PLANET

STAR BRIGHTNESS:
● MAG. 0 & BRIGHTER
● MAG. +1
● MAG. +2
● MAG. +3
· MAG. +4 & FAINTER

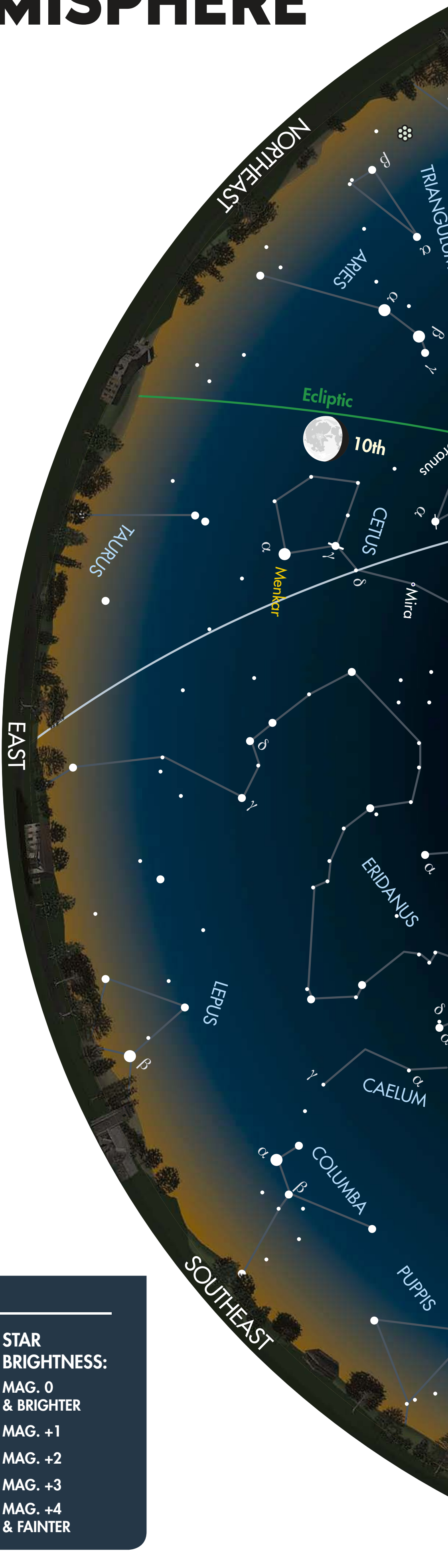
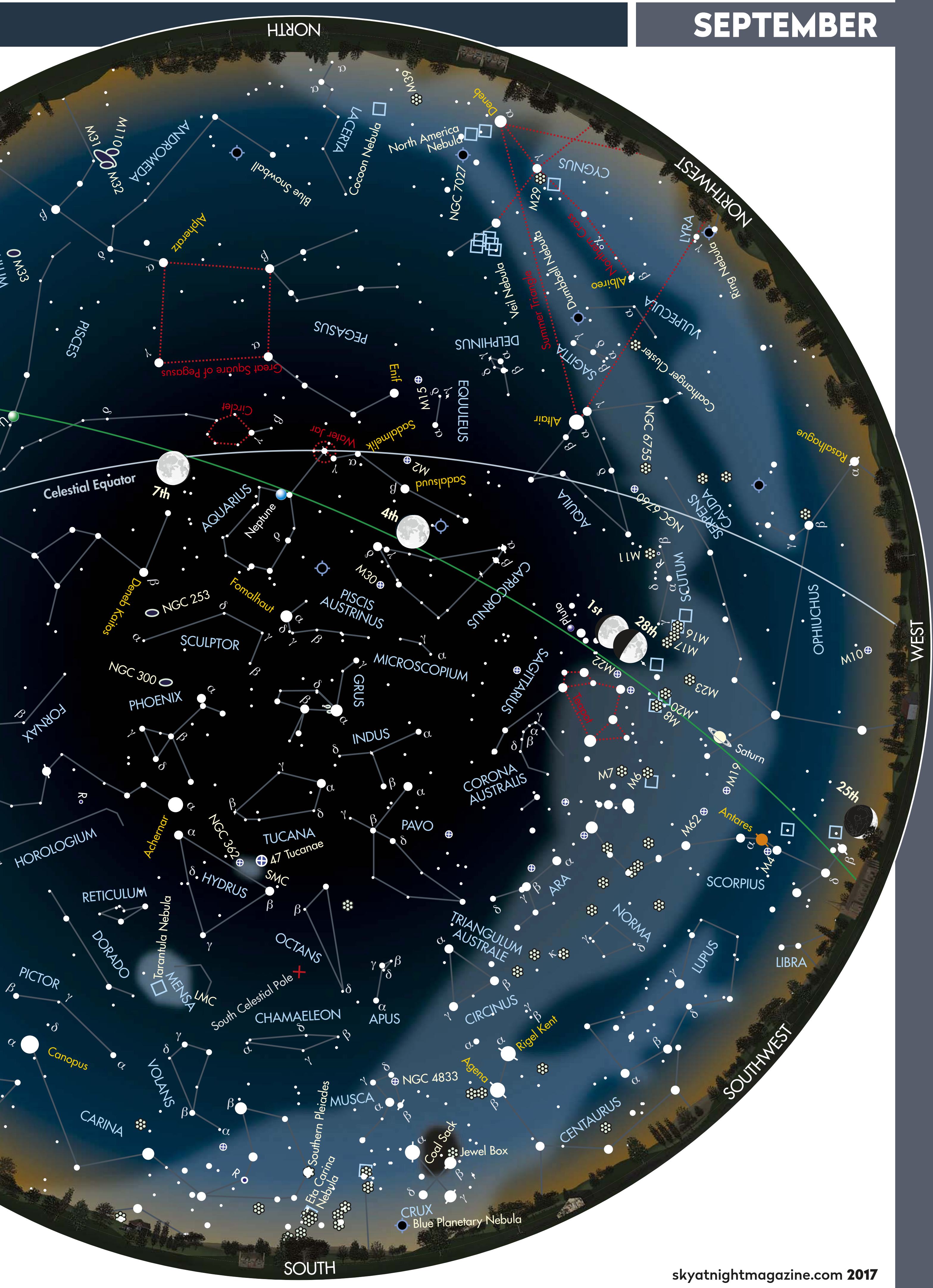


CHART: PETE LAWRENCE, IMAGE: MICHAEL BREITE / STEFAN HEUTZ/ WOLFGANG RIES/CCDGUIDE.COM


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
M39
Deneb
LACERTA
Cocoon Nebula
North America Nebula
NGC 7027
CYGNUS
M29
Blue Snowball
ANDROMEDA
M110
M31
M32
M33
Alpheratz
LYRA
Ring Nebula
Veil Nebula
Dumbbell Nebula
Northern Cross
Summer Triangle
Albireo
VULPECULA
PEGASUS
DELPHINUS
SAGITTA
PISCES
Great Square of Pegasus
Coathanger Cluster
Enif
M15
EQUULEUS
Altair
NGC 6755
Circlet
Water Jar
Sadalmelik
Rasalhague
Sadalsuud
M2
Celestial Equator
7th
AQUARIUS
Neptune
4th
AQUILA
NGC 6760
SERPENS CAUDA
M11
SCUTUM
OPHIUCHUS
M10
Deneb Kaitos
NGC 253
Fomalhaut
M30
PISCIS AUSTRINUS
CAPRICORNUS
Pluto
1st
28th
M16
M17
SCULPTOR
MICROSCOPIUM
M22
SAGITTARIUS
M23
Teapot
M20
M8
NGC 300
PHOENIX
GRUS
FORNAX
INDUS
Saturn
M19
M7
M6
CORONA AUSTRALIS
25th
Achernar
NGC 362
TUCANA
47 Tucanae
SMC
PAVO
HOROLOGIUM
M62
Antares
M4
HYDRUS
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